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RESEARCH ARTICLE

GEOMORPHOLOGY OF GARHWAL HIMALAYA, PARTS OF CHAMOLI TEHRI UTTAKASHI & PAURI UTTAR PRADESH (UTTRARKHAND) INDIA

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Abstract

The Geological and Geomorphological study in Upper Ganga basin has been attempted in parts of de Uttarkashi,Chamoli, Pauri and Tehri districts an area of 10000 Sq.kms in parts of QA sheet 53Jand 53 N on 1:50000 scale of Garhwal Himalaya U.P; presently known as Uttrakhand State of Union of India. Out of total area of study, an area about 3500 sq.Kms has been selected for detailed Geological, Geomorphological and Sedimentological study. The area of Upper Ganga basin consisting of Alaknanda,Bhagirathi,Bhilangna, Nandakini, Mandakini, Pindar, Dhauli- Ganga Bal- Ganga , Madhmeshwar Ganga and Berhi Ganga The Alaknanda is chracterised by six terraces followed by Bhagirathi with five terraces , Bhilangna Nandakini four terraces Mandakini /Pindar/Dhauli-Ganga /Balganga three terraces , Madhmshwar Ganga two terraces and Bberhi Ganga one terrace,amidst these Alaknanda is trunk stream and others are tributaries. Geomorphologically the area is divided in to seven geomorphic units viz High relief formerly glaciated area, Structural hills, Denudational hills, Area of mass wasting, High level dissected fans, river Terraces and Present day flood plain of Alaknanda and its tributaries . These units area developed in response to lithology to erosional land depositional activities and tectonic in which they are embedded. Each unit is characterized by drainage, diagnostic geomorphic landform elements and features, photo charcters and morphogenetic expression. The other geomorphic features and elements identified in the area are point bar, channel bar, alluvial fans ,talus cone , rock cut terraces fan cut terraces , abandoned channel ,epigenetic gorges, strand lines landslides ,rock fall scree and scree slope, retreating scarp, abandoned cirque, arêtes, threshold, horn peak and glacial lake. The area genetically comprised of terraces of three domains, viz. Glacial, Fluvio-glacia and Fluvial which represent distinct environment of sedimentation of Pleistocene, late Pleistocene and Holocene time during Quaternary period. The Glacial terraces are identified at an average elevation of 1150 m above MSL, the fluvio-glacial terraces at an average elevation of 975m above MSL and Fluvial terraces at an average elevation between 650 to 900 m above MSL.

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Introduction:-

The Geological and Geomorphological study in Upper Ganga basin has been attempted in parts of de Uttarkashi,Chamoli, Pauri and Tehri districts an area of 10000 Sq.kms in parts of QA sheet 53Jand 53 N on 1:50000 scale of Garhwal Himalaya U.P; presently known as Uttrakhand State of Union of India. Out of total area of study, an area about 3500 sq.Kms has been selected for detailed Geological, Geomorphological and Sedimentological study.

The Dehradun and Rishiksh are nearest rail heads of Northern Railway of area of study. These heads are connected by good moterable roads leading to famous pilgrimage centre Badrinathh , Kedarnath , Gangotri and Janmnontri. The state highway No 54 which is connecting Rishikesh and Badrinath bifurcates at Rudraprayag along Mandakini river and terminates at kedarnath via Sonprayag.. The Tehri is about 85 kkilometers from Rishikesh on state high way No 53 connecting Rishikesh –Tehri Uttarkashi Gangotri .This road runs along Bhagirathi river between Tehri and Gangotri. A bifurcation from Tehri Gangotri bifurcates at at Dharasu and connects Bhagirathi valley to Yamuna valley crossing the water divide at Ravi pass.In addition to these , there are fare fair roads which connects Kathgodam to Karanpryag via Ranikhet ,Dwarhat and Adi-Badri from east and Mussoori via Dhanaulti to Tehri from west to Alaknanda and Bhagirathi valleys respectively.(Plate No.1 & 2)

Previous Work

The area of Upper Ganga basin consisting of Alaknanda,Bhagirathi,Bhilangna, Nandakini, Mandakini, Pindar, Dhauli Ganga Bal ganga , Madhmeshwar Gangaand Berhi Ganga amidst these Alaknanda is trunk stream and other are tributaries. These stream emerge from different glaciers in Himalaya and decennd in sinuous to meandering channel pattern. In their courses they traverse through entrenched valleys, and deep gorges leaving glacial Fluvio-glacial and Fluvial terraces in decreasing antiquity due to uplift and climatic changes in the area representing different phases of sedimentation in Quaternary period.

Padhi and Sharan (1972),Dubey (1974a) , Shukla Khan & Dubey (1973)Khan (1974) Dubey (1974b)Sinha & Khan (1976)have carried out geological and Geomorphological studies in parts of Alaknanda, Bhagirathi, Bhelangna, Bal-Ganga, Jalkhur , Pindar Atta Gad and Jamuna valleys.

Present Work

The present paper is an attempt to trace integrated picture of geomorphic evolution, stratigraphy of terraces of various domain, their correlation in Upperr Ganga Basin during Quaternary period.

The area under study has witnessed the intensive erosional and depositional activity subsequent to recession to glaciers which has entirely modified the pre-existing, topography and given rise to seven morphogenetic regions, (Khan, 1981 and Khan et al, 1981). These regions have been developed in response to lithology of the area to erosional and depositional activity and regional tectonics in which they are embedded, (Khan 1981). The glacial, inter glacial and post glacial climatic conditions, have also played the vital role in morphogenetic shaping of present day complex. These regions are delineated in the area based on their genesis, and associated diagnostic landform elements and features, (Khan 1982). Their tentative sequential order of development is as follows: (Plate No. 3)

1. High relief formerly glaciated area;
2. Structural Hills;
3. Denudational Hills;
4. Area of Mass wasting;
5. High level dissected Fans;
6. River Terraces;
7. Alluvial Plain.

Hige Relief Formerly Glaciated Area:

The formerly glaciated area mainly comprises sharp crest asymmetric and symmetric ridges of gneiss, granite, schist, quartzite and metavolcanic rising to an average height 3050 m above the m.s.l. It is characterized by typical glacial and peri-glacial topography embracing numerous glacial and peri-glacial features such as abandoned cirques, eroded threshold, subdued regional arêtes, horn peaks, cliffs and glacial lake, (Khan 1987). This area is mostly restricted in north, northwestern part of the area under study in the headword ends of Alaknanda, Bhagirathi and

Bhilangha, Mandakini, Nandakini and Madhmeshwar Ganga, these snow fed river valley in this area have typical U-shaped flat bottom with the small V-Notch of the base indicating the superimposition of fluvial cycle of erosion on these pre-existing old glaciated valleys in the recent past.

These valleys are characterized by numerous ternary land forms of glacial, fluvio-glacial origin such glacial, fluvio-glacial terraces and cirque moraines. The cirque moraines descend in the valley from the side and forms the conspicuous series of isolated and coalescing cones in the valley floor, which generally taper off upward and their apex partly touches the threshold of a abandoned cirque and often terminate against them. (Photo No. 9 to 12). The abandoned cirque are commonly associated with active and recent landslide in the area as seen in the headword ends of Ganesh Ganga and around Tapoban in Dhauli Ganga. The most of cirques are located in east-west trending ridge. They are mostly associated with active glacier in the area. But there are many cirques in the watershed region of Bhagirathi, Bhilangna, Madhmeshwar Ganga and Pindar which are devoid of any snow and ice. The assorted rock debris and fine sediments within the cirques are seen occasionally covered by thin veneer of fresh snow. Though the majority of Cirques are semi-circular in shape, but semi-elliptical or even rectangular cirques are not uncommon. In the northwestern part of the area few composite cirques (small cirques within a large cirque) are also noticed, Cirques which are filled by fresh snow are termed as nivation cirque.

In the upstream of Mandakini in north of Kedarnath temple number of well developed cirques were identified on the aerial photographs, they are mostly arm chair shaped hollows with a steep to vertical head walls, concave floor and a threshold these cirques are noticed at an average height of about 4500 m.

The glacial lakes seen in the area are mainly three types, one occurs at depressed bottom part of empty cirque which are known as tarn. The other type occur along the glacier valley between lateral moraine and side wall of the glacial trough. Many small lakes occur along linear depression on the glacier itself, either on the ice in the surfacial moraines. These are called pre-glacial lake. In the watershed of Mandakini several glacial lake and Cirque Lake were identified with the aid of aerial photograph. The prominent lake observed are Panya Tal at an elevation of 4700 m. Vasuki Tal 4400 m. and Bisuri Tal at 3900 m. A number of small lakes are noticed in northern part Northwest of Dautulia Tibba, lake occur in the deeply scoured depression of these cirques and contain water even during the summer. The majority of them can be grouped under Cirque Lake.

In the north-western part of the area, two cirque lakes are observed at different levels on the east facing slop. It is very clear on the photographs that these have occupied the concave depression, a normal product of cirque glacier erosional activity. The two successive levels of these lakes indicate lower one is the older and thus representing upper one an aerial stage of glaciations such cirques are called tandem cirque.

The prominent lake of the area, Vasuki Tal also occurs in the deep scoured part of cirque. In the upper reaches of Vasuk Ganga, northwest of Vasuki Tal, few depression in the valley at different levels are seen. These were formed by differential scouring by the valley glacier, which once extended south. These depressions were connected by the stream and appear as springs along the valley wall.

Another beautiful glacial lake observed is the Blsuri Tal in the south east, this also occurs in the cirque depression. These lakes are often surrounded by glacial drift material.

Spectacular features of glaciated mountain are aretes, which are steep serrated ridges and horn peaks, which rise to high levels. The northern part of area of study have unmistakable assemblage of these features. Arêtes were formed by encroaching of cirque. A number of horn peaks which were formed at the junction of arêtes are found in the area. Prominent amongst these are the Mandani Peak 6193 m. North of Gopeshwar.

The hanging valleys are seen in the upper reaches of Alaknanda around Joshimuth, Hanuman Chotti, in Bhagirathi near Sukhi, Gangani, in Bhilagna upstream of Ghansali, in Mandakni near Kedarnath temple, in Pindar upstream of Nandikesri, in Nandakini upstream of Ghat. These hanging valleys are associated with water fall. The V-into U-shaped valley is common features seen in the upper reaches of Alaknanda and its tributaries which were formed by superimposing of glacial cycle over the fluvial one.

It is interesting to note that glaciers trending E-W direction are larger in size than the others. The glacier facing north or south direction are smaller in size and are mostly hanging in nature and are associated with more permanent avalanche tracks which are generally very smooth concave in nature with deep grooving on the surface.

In the Satopanth area, one south facing small glacier is seen over riding the main glacier; similarly another south facing glacier of Bhiandhar Ganga is seen coming down over the main glacial trough pushing scouring debris in the main valley forming glacial cone along valley flanks.

Innumerable crevasses in definite pattern are seen in eAlaknanda around Joshimuth, Hanuman Chotti, in Bhagirathi near Sukhi, Gangani, in Mandakni near Kedarnath temple, in Pindar upstream of Nandikesri, in Nandakini upstream of Ghat along entire length of the glacier. In the amphitheatre. Part of cirque crevasses form circular pattern which ease out glacier movement by the convexity of crevasse which thrust out ground moraines across the threshold in the valley. (Plate No.8 Unit No.VII).

Structural Hills:
It is obvious that the landforms result primarily due to erosion rather than deposition show conspicuous influences of lithology and structure in varying degree depending upon the differential competency of rocks, degree of dissection, drainage development and disposition of the rocks exposed to erosion.

The present area of study constitute the parts of inner lesser Himalaya and outer edge of the Central Himalaya, 1thologically comprise of three distinct group of rocks viz. north to south (i) the Central Crystalline group (ii) Garhwal group and (iii) Dudatoli group, each group is separated either thrust or fault. These different groups comprise of gneiss granite, schist, quartzite, phyllite, limestone and meta volcanic, exhibit the imprints of neotectonic activity in the area, These rock units form both strike and randomly oriented symmetric and symmetric ridges, the later being most common in the area perhaps due to folded nature of the terrain. At few places particularly near the nosal portion of anticline and syncline the ridges are curvilinear and follow the strike. In general the crest lines exhibit sub-rounded to rounded characters and is mostly characterized by retreating and joint control scarps. The drainage system is mainly influenced by net work of joints, faults and fracture pattern resulting in a sub-parallel to parallel and rectangular drainage pattern.

The most prominent structural hills delineated in the area are Nagthunga Maithana syncline, Chattopipal anticline and Rudraprayag anticline.

The Nagthunga Maithana syncline has NW-SE axial trend and plunge in the southeast direction. In the north, the closure of syncline is cut off by a curvilinear lineament around Kalsir. It comprises both strike and randomly orientated ridges.

The Chatipipal anticline is overturned plunging anticline with regional axial trend in NW-SE direction. The North West extension of the fold axis is cut off in Alaknanda valley around Gauchar by E-W trending Alaknanda fault.

The structure of western part of the area appears to be much more complicated. The most important structural elements in doubly Rudraprayag anticline, with axis trending in ENE-WSW , which abuts against the Alaknanda Narkota and Rudraprayag , it forms the anticinal valley and Alaknanda partly curves its course along the axial plane. The Kaliyasaur fault on west swings and offset the Rudraprayag anticline axis The huge active landslide of rotation nature near Kaliyasaur is related to this fault. (Plate No .8 Unit No VI).

Denudational Hills:
The denudational hills predominantly comprises quartzite, slate, phyllite, limestone and basics and are characterized by symmetric to asymmetric moderately sharp to sub- round crest lines rising to the average height 0f 1870 meters above m.s.l. These hills were subjected to varying degree of dissection and are still under the active influence of different erosional processes. The chief erosional pattern recognize in these hills are accelerated headword erosion, deep gully erosion, rill erosion and at places sheet erosion. The stream running these topography have generally steep gradient and carry some sediment load from the headword ends and deposit it either on their terminus or open in to t higher orders streams. It is the endless process a dual way of one end trimming and smoothen the relief , and other forming the abundant talus cone sand alluvial fans in the hill front region.

The major part of these hills is drained by Aalknanda, Mandakini and other tributaries. The other primary, secondary and tertiary streams also drain these hills which are generally obsequent, subsequent, insquent and consequent in nature and give overall denderitic look to these hills (Plate No. 8 unit NO.IV)

Area Of Mass Wasting:

It is characterized by the presence of numerous mass wasting processes, viz. landslide, rock fall, debri fall, slump and scree etc. It is interesting to note that some of the major landslides of rotational nature are either located close to the prominent lineaments such as Kaliyasaur, and Nandaprayag slides, in Alaknanda valley or associated with the remnants of abandoned cirques in the peri-glacial areas, such landslides are seen around Hanuman Chatty in Alaknanda Tapoban in Dhauli Ganga, in the headword ends of Ganesh Ganga, around Berhi and north of Okhimuth in Mandakini valley (Plate No.8 Unit No.V). It is evident that movements along the major lineaments, however small in magnitude be, are still taking place in Himalaya. Similarly in the Peri-glacial area the rocks have been rendered week because of prolonged coverage by ice cap and shattered due to the periodic thawing and freezing of the ice cap. Further the post-glacial activity and seasonal variations in these areas have substantially enhanced the resistivity of these rocks on sliding, both under the action of gravity and climatic hazards. The selected case histories of prominent landslide in Alaknanda, Bhagirathi, valleys are discussed below.

Kaliyasaur Landslide:

In Alaknanda valley the prominent landslide of Kaliyasauris located about 21 km. upstream of Srinagar in topo sheet No. 53J/16 in Pauri district has been studied..The slide had occurred first on the 19th September 1969 at km. 147 below the village of Chantikhal on the Reshikesh- Joshimath road. During the first slide a considerable size of material is reported to have moved down the slope to the original road which lay about 75 to 92 m. (250' - 300') higher than the river level, and to have practically blocked about three fourth of the width of the river. This temporary blocked of the river had, however, been washed out by the end September 19 1969. The first slide, though initiated on the 19th September 1969 and reported to have been active till the 23rd September thereafter it is reported that it becomes more or less quiescent along most of its length, though the upstream and downstream - edge of the slide was still slightly active even when the road was tentatively reopened to traffic on the 14th October, 1969.A mild earthquake shock was reported to have been felt by the villagers of Chantikhal and Khankra and in adjoining areas on the 23rd September 1969. The reported earthquake of the 19th September 1969 could not be substantiated by any instrumental data. It is also on records that minor landslides had occurred in this area in 1952, 1963 and 1965.

The climate of the area is cold with annual rain-fall of about 60" (1500mms) spread over the 3 months of monsoon and over nearly 1½ months of winter. No snow-fall is reported from this area in a normal winter season. It is digenetic that considerable precipitation, extending continuously over 5-6 days, is reported to have occurred up to the 16th September 1969 in the slide area. There was flood in the Alaknanda River on the 19th, September 1969 when the river level had risen by about 3-4.5 m. (10-15 ft).

The river Alaknanda is antecedent river and has straight and meandering pattern cutting across rugged terrain of Himalaya, in the area of landslide it takes a sharp turn resulting acute angled bend near the toe of the slide area, resulting active erosion of the toe of the slide causing constant sliding of land mass. . The river level is understood to rise up by as much as 20' during normal floods, which submerges toe of the slide aggravating mass movement.

There are a number of natural springs emerging from the hill slope just below the village of Chantikhal. However, most of the nalas and stream are dry between the level of these springs and a point 45 m. (140') above the Alaknanda River. The spring water generally disappear in the debris of slide and re-appear down the toe of the slide in the form of small branching channels ultimately joining Alaknanda river, The anomalous behavior of stream water and distribution of the springs in vicinity indicate the major disruption in the system or surface drainage by mass-wasting activities in the recent past. The dislocation in the normal path of drainage and development of internal hydrostatic pressure due to loss of stream water has further been aggravating the land slide problem in the area.

The area of Landslide encompasses the rocks of the so called “Chamoli window series" and lies about 2 to 3 km. north of the Srinagar thrust. The rocks exposed in the slide area are white and purple gritty quartzite, with minor bands of purple and leaf green shales varying in thickness from a few cms to maximum of 1.5 m. The rocks are very well bedded and show typical ripple marks. They are openly folded, but have a general dip 40° to 50° in 835°C to 530°W direction. The most prominent joints have dips of 40° to 55° in N60°W direction and 70° to 80° in N150°W

direction. These joints are open as by much as 2-10 cm. at places and are very continuous and consistent in nature. Besides these prominent sets, a number of other minor sets of joints, dipping in westerly and in south-easterly directions are also present. In the slide area the rugged terrain, two prominent bedding shear zones (or fault zones) have been traced In fact, the most prominent one of these zones could be traced for a distance of nearly over km. along its strike, and consists of highly crushed and powdery quartzite. In the shear zones the rocks has practically lost all its hardness and cohesion, and the fragments of rock could be reduced to rock flour by rubbing them between the fingers. The two shear zones are probably shifted up along a transverse fault which forms the prominent saddle near the Chantikhal Forest Rest House.

Probable cause of the slide

The landslide cannot be ascribed to particular cause and a combination of causative factors has to be considered. The most important causative factor appears to be extensive toe erosion by the river at the turning point in its course, where, in addition to the scouring by velocity of low, it was hammering and disintegrating the rock by impact. In fact there must have been a gradual process of failure of the toe as is evident from a study of air photos. and topo-sheet In the 1920's according to the topo- sheet, scarp, nearly 30 m. (100 ft.) high or even more, has been shown at the river level, whereas, it is reported that prior to the recent slide there was a rock ledge only about 15 m. (50 ft.) in height. This gradual removal of the toe support and lessening of the path of percolation of water o the major bedding shear zone, occurring near the toe was a major contributory factor in causing the slide. This shear zone, under saturation, must have tended to settle and to disturbed the whole slope which was probably in a state of limiting equilibrium.

The second contributory cause appears to be the extensive precipitation spread over a week prior to the slide. This may have resulted in heavy saturation of the slope forming material and the high flood in the river and must have eroded and saturated the toe to an extent sufficient to trigger off the slide in an area which was already in & state of critical equilibrium.

The third contributory cause seems to be the inherent weakness of the jointed rock mass and its poor conation in the zones, Moreover, due to the well known phenomenon of stress relief near a valley wall, the joints have all opened up in tension, by as much as 2 to 10 cm. thereby, further weakening the already weak rock. It appears that a portion of the zone affected by stress relief has moved out in the present slide. Unless further movement of this portion is controlled, the upper levels of the stress-relieved mass may be affected in the course.

Dangla Landslide Bhagirathi Blockade Around Dabrani

In August, 1978 the Kanuldia Gad is a small tributary of Bhagirathi which rise from snow clad peak about 3200 north West of Dangla it joined by another small streams the Gidaraki Bad at 3050 m. and Thiria Gad, which drain north and western portion of catchment. The Kanodia Gad ultimately mingles with Bhagirathi north of Gagnani. The gradient of Kanauldia Gad about 2 km. upstream of confluence of Bhagirathi is of order 235 m./km. In August 1978 this stream has brought out a huge quantities of rock debris and blocked the Bhagirathi forming a huge natural dam causing the serious danger to life and property in the region.

The area of study comprises crystalline group of rock consisting of gneiss, kyanite mica schist, garnet mica schist, and intruded augen gneiss granite marble, migmatite zone of mica schist, tourmaline, banded gneiss amphibolites marble and calc-silicates. This group of rock is separated by green schist facies rocks of Garhwal group by northerly dipping Central Himalayan. Thrust which has been traced south of Bhatwari near Sainj.

The Quaternary sediments comprises of two distinct units viz. the river borned sediments of Fluvial terraces of Bhagirathi, and heterogeneous assemblage of rock clastic of glacial moraines and glacial outwash and the active flood plain deposit of Bhagirathi. The former group of sediments mostly confined along the higher parts of valley flanks in the form of isolated pockets and lenses representing the former level of valley floor, where as later along the active course of Bhagirathi. Plate No.4)

Causes of Formation of Artificial Dam Around Dabrani :

The natural dam was formed about 3 km. upstream Gagnani in the Bhagirathi valley at the terminal of Kanuldia Gad. The natural damming has been resulted due to any one of the under mentioned factors, or due to cumulative effects of these parameters,

(i) The Bhagirathi in the area round Bhatwari and Dabrani in parts of Uttarkashi district descend through a glaciated valley, which has a small V-notch at the base; as such it is U-into V-shaped valley and formed by the Superimposition of fluvial cycle over the glacier in the recent post. The steeply rising walls of the valley in the area are occupied by the discontinuous caps and strips of glacier moraines of variable thickness. These moraines in general consist of heterogeneous suite of rock fragments ranging in small pebble to large boulder in the matrix of coarse to fine sand silt and clay. These sediments are mostly un-consolidated and assorted in nature and generally devoid of bedding. The torrential down pour in August, 1978 in the area has super-saturated the piles of these un-consolidated sediments, subsequently experienced the mass movement under the action of gravity and supplied huge quantity of debris load in the valley.
(ii) The area comprised of crystalline group of rocks consisting of gneiss, schist, and granite, marble. These rocks are easily susceptible to erosion and embrace innumerable planes of weakness, joints, faults which has caused the several features of mass wasting activities like landslide, rock fall, Debris fall, along the right flank of Bhagirathi near Dabrani. The excessive precipitation in August, 1978 appears to have reactivated these landslides and had supplied the excessive Debris load in the valley which perhaps caused the chocking of Bhagirathi around Dabrani.
(iii) The Kanauldia Gad has its water shed in the area of mass wasting activities, glacial cirque which contain large quantity of loose and unconsolidated rock debris in the form of cirque moraines, ground moraines, talus cone. The cloud burst and excessive rains in August, 1978 appears to have mobilized these piles of unconsolidated sediments, rock Debris both from glacial front and mass-wasting faces and rapidly transported and accumulated the same at the terminal of Kanuauldia Gad in Bhagirathi valley forming a natural dam around Dabrani.

The Dhangla landslide also appreciably contributed the debris load in the valley.

Among the above process mass wasting appears to be the main cause of natural damming of Bhagirathi around Dabrani in August 1978.

High Level Dissected Fan And Sloping Surfaces:
These dissected fans and surfaces have occupied the higher parts of valley flanks in Alaknanda, Mandaldni, Nandaldni and other tributaries at an average elevation of 860 m. above the m.s.l. The average slope of these fans and surfaces ranges from 10° to 15o and are mostly controlled by the topography and disposition of the bed rock.

These were formed by series of alluvial fans deposited distinctly in piedmont environments by numerous subsequent streams draining in the valley. These streams generally had steep gradient, high load carrying capacity, and sudden discharge characteristics. The continuous process of transport of the sediments load from the headword ends and formation of numerous alluvial cones and their subsequent coalescences had led to the formation of these fans and surface during the initial stages of valley development, (Khan et. al. 1983).

The streams subsequent to the formation of these surfaces were formed to adjust their base level in relation to the trunk stream due to micro-pulses of uplift/microclimatic changes and cyclic rejuvenation of the major streams, which incised through their own deposits, leaving behind these high level fans and surfaces in the stage of high denudation along the valley flanks.

Schistose rocks, slate in. Alaknanda between Koteshwar and Devprayag, Rudrapryag and Nagresu there is tendency of the river to form wider flood plain as compared to the other rock units, due to easy erodibility and effective utilization of stream energy of stream both in lateral and vertical cutting. These streams at places have also adjusted themselves long the weaker planes during the upraise as evident from the straight segments of channel and steep and linear alignment of the scar lines along the valley slopes, where the stream did not find any weaker planes to adjust inspite of upraise and undergoing phase of increasing discharge and passing through the steep gradient, the stream accommodated discharge by lateral swing and gliding over its own deposit and had effectively consumed its enhanced energy, added to it by upraise, discharge and gradient, by lateral cutting on the nose of the tight meander.

The geomorphic features and land forms associated with this unit are point bar, channel bar, channel braids, riffle and pools, scarps fossil channel coarses and lateral cutting. The point bar, sand bar are depositional features and are mostly associated with the flood plain of stream. The point bars are formed on the convex bank of the slip off slopes generally in the sinuous to meandering stretches of the channel; whereas.

These fans and sloping surfaces are characterized by deep gully erosion, extended gullies, impersistent and partly internal drainage, high drainage density and degree of dissection due to very coarse and loose texture of sediments in contrast to the other morphogenetic regions. These fans and surfaces are characteristically composed of sub-angular to sub rounded boulder, cobble, pebble predominately of quartzite, gneiss, granite, slate, basic, phyllite in the matrix of coarse to fine silt and clay with subordinate amount of sand. As a whole, the entire assemblage of sediments is very poorly sorted and devoid of higher degree of sphericity-roundness and sorting indicating the close proximity of their provenances. (Plate No.8 Unit No. iii).

River Terraces:

The river terraces or alluvial topographic 'benches! form the prominent Quaternary landscape flanking the Alaknanda Nandakini, Mandakini, Pindar and Dhauli Ganga breaking the monotony of vast rugged hilly tracts. These terraces are the abandoned flood/plains of river and as such indicate the former levels of valley floor. These were formed by a cumulative action of erosional and depositional processes of streams related with the up warping in the headword ends and consequent climatic changes in the post Pleistocene time, (Khan 1976-77).

Quaternary Terrances of Alaknanda and its Tributaries

6.1 Glacial Terraces
6.2 Fluvio-glacial Terrance
6.3 Fluvial Terrances
6.4 Longitudinal Profile of Alaknanda and its Tributaries
6.5 Geomorphic Evolution of Fluvial Terraces in Alaknanda and its Tributaries.

The sequence of terraces and of valley development in upper Ganga Basin (Jhanson 1944, Saran 1970, 1972 and Khan 1975-76).

Table 9:- Stratigraphy Of Quaternary Deposit In Upper Ganga Basin, Garhwal Himalaya U.P.

Age	Quaternary Formation	Environment of sedimentation	Geomorphic land forms	Composition
	Younger Alluvium	Channel and Flood Plain	Flood Plain Point Bar, Channel Bar Sand Bar	Well rounded boulder, cabble, pebble of quartzite, gneiss, schist, granite, slate, limestone, phyllite and basics in the matrix of coarse to fine micaceous sand.
Holo cone Older Allu vium	Fluvial deposit	Channel and flood plain	River terraces of Alaknanda and its tributaries	Sub-rounded to well rounded boulder, cobble, pebble of quartzite granite, gneiss, schist, phyllite, slate, limestone and basic in the matrix of coarse to fine sand silt with subordinate amount of clay
Late pleis-tocene	Fluvioglacial glacial deposit	Fluvio glacial	Fluvio glacial terraces of Alaknanda & its tributaries	Sub- Angular boulders, cobbles, pebbles of quartzite gneiss, granite biotite schist, muscovite, chlorite schist, slate and basic, in the matrix of coarse to fine sand, silt and clay.
Early pleis-tocene	Glacial deposit	Glacial	Glacial terraces, terminal moraines medial moraines, cirque moraines of Alaknanda &	Sub-Angular to angular boulder, cobble, pebble of gneiss, granite, quartzite, granite, quartzite, biotite,

			its tributaries.	muscovite, chlorite schist, in the matrix of very coarse to very fine sand, silt and clay

The successive development of Quaternary terraces of Alaknanda is as follows: -

Table 10:- Stratigraphy of quaternary terraces in upper ganga basin, garhwal himalaya U.P. India.

Age	Stages of valley development	Terraces	Environment of sedimentation
Recent to Holo-cene		Flood Plain and adjoining low land area of present day course of channel and associated geomorphic features, point bar, sand bar, channel braids etc.	Channel and Flood plain environment
	VI	Berhi Ganga terraces	BRT_1
	V	Madhmeshwar Ganga terraces	MDT_1 to MDT_2
	IV	Bal Ganga terraces	MDT_1 to BGT_2
		Mandakini terraces	MT_1 to MT_3
		Pindar terraces	PT_1 to PT_3
		Dhauli Ganga terraces	DGT_1 to DGT_3
	III	Bhilanga terraces	BHT_1 to BHT_4
	III	Mandakini terraces	NT_1 to NT_4
	II	Bhagirathi terraces	BGT_1 to BGT_5
	I	Alaknanda terraces	AT_1 to AT_3

Late – Pleistocene Flurio-glacial terraces Flurio-glacial of Berhi Ganga, Madhmeshwar Ganga, Balganga, Mandakini,Pindar, Dhauli Ganga, Bhilangna, Nandakini, Bhagirathi and Alaknanda

Pleistocene - Glacial terrances of Berhi Ganga, Glacial Madhmeshwar Ganga, Bal Ganga, Mandakini, Pindar, Dhauli Ganga, Bhilangna, Nandakini, Bhagirathi and Alaknanda.

Glacial Terraces :
These are the high level terraces and their occurrences are restricted above an average elevation of 1150 m upstream of Nandaprayag in Alaknanda, upstream of Uttarkashi in Bhagirathi, upstream of Kund-Chatti in Mandakini and upstream of Thirpak in Nandakini valley. These terraces constitute the oldest sequence of Quaternary sediments in the area and are seen in stage of high denudation as isolated pockets and lenses along the higher parts of valley flank.

In Alaknanda valley the occurrences of these terraces are noticed around Chamoli, Pipalkoti, Marwari, Pandukeshar, Hanuman Chatti, and Badrinath. In the vicinity of Badrinath, four levels of the glacial terraces (side moraine/lateral

Moraine) have been identified, besides the terminal moraine and cirque moraine. These terraces on left flank of Vishnu Ganga constitute stepped sequence representing the former levels of valley floor. Each segment of these terrace is separated by a ill-preserved and highly dissected scarp, which have mostly subdued sharpness and convex slopes due to prolonged erosion and debris slides subsequent to their deposition in the valley.

The cirque moraine comprises both coalescing and isolated talus cones descending in the valley from the sides. These cones characteristically taper off upward and terminate against the eroded thresholdes of abandoned cirque. At places, in the valley, such as around Badrinath and Hanuman Chatti and Gobindghat, the apex of these cones partly touch the outlets of cirque depression which is suggestive of activeness of these glacier in recent time.

The type development of this cirque moraine as talus is seen in Joshimuth Badrinath section in Vishnu Ganga, Joshimuth Tapoban in Dhauli Ganga. These were mostly formed during the descend of numerous cirque glacier in the valley in the pleistocene time..

The glacial terraces consist of heterogeneous assemblage of sub angular to angular, unsorted, unstraitified rock fragments ranging from big boulders to small pebbles in size predominantly of gneiss, granite, quartzite and highly

weathered biotite muscovite and chlorite schist in the matrix of very coarse to fine sand, silt and clay. These rock clastics are largely angular, very poorly sorted; display isotropic imbrications pattern and are devoid of bedding.

The fine sediments comprise of light smoky coarse to fine sand with appreciable amount of mica flakes; light to dark maroon silt and clay, light brown coarse sand with sub-ordinate amount of silt and dark red and yellow sand with silt. The sand matrix contain fairly good amount of quartz and feldspar grains and loosely composed mica flakes. These sediments around Hanuman Chatti display lamination and cross lamination indicative of trough like sedimentation which might have been formed by chocking of the valley during the glacier advance in Pleistocene time.

Fluvio-glacial Terraces :

The fluvio-glacial terraces are noticed at an average elevation of 975 metres above the m.s.i. and their occurrences are restricted to a small stretch between Nandaprayag and Chamoli in Alaknanda. These terraces are sandwiched between the glacial and fluvial terraces as these terraces abut against the glacial terraces on the upstream side and fluvial terraces on the downstream and as such these represent the transitional phase of sedimentation.

These are characterized by sub angular to sub rounded boulder, cobble, pebble of quartzite, gneiss granite, slate and decomposed highly weathered biotite, muscovite and chlorite schist in the matrix and coarse to fine sand, silt and clay. The fine sediment consist of light brown coarse to fine sand and silt, very coarse of fine micaceous sand, light to dark maroon coarse to fine silt, and clay light smoky sand with subordinate amount of silty matrix, yellow to orange coarse to fine sand and silt. These sediments contain appreciable amount of quartz, feldspar and basic grains with partly decomposed mica flakes. These finer clastic constitute small bands in alternation with parting of mica flakes and coarse sandy granules, which are generally seen embedded with underlying and overlying small pebble horizon comprising predominantly of grey, pink, yellow, cream, smoky and green quartzite, grey, pink and white felšpathic gneiss, granite and dark brown, green biotite and chlorite schis7).

Although the sediments of these terraces are similar in texture and composition to glacial terraces, these exhibit entirely different order of sedimentary pattern and sediment character. In contrast to the glacial terraces, these sediments display moderate degree of sphericity roundness and sorting and show preferred orientation pattern. The ill-preserved sedimentary features and long interval cyclic development of bedding is also conspicuous. These associated diagnostic sediment characters, sedimentary features and disposition of these deposit indicate an intermittent and rapid reworking of the sediments from the glacial front subsequent to the melting of glacier during the late Pleistocene times.

Fluvial Terraces:

The fluvial terraces or alluvial topographic benches of Alaknanda and its tributaries form the prominent Quaternary landscape in the valley breaking the monotony of vast rugged hilly tract.. These terraces are formed by a combined intermittent process of aggravation and degradation in the valley associated with different phase of sedimentation of the fluvial domain. As such others are the abandoned flood plains of the river representing the former levels of valley floors and formed due to tectonic eustatic and climatic changes during the Holocene time, (Sehgal et.al. 1982, Khan et.al. 1984).

These terraces are comprised of sub rounded to well rounded boulder, cobble, pebble of predominantly quartzite, gneiss, granite and schist basic, slate, phyllite, limestone, in the matrix of sand and silt with subordinate amount of clay.

In Alaknanda valley, these terraces are characterized by the association of fossiliferous boulder, cobble, and pebble of quartzite with the luxuriant assemblage of products, spirifer and other species of Brachiopods and Mullosc group typically of permo-carboniferous age. Although these rock constituents are common in these terraces, but their conspicuous concentration is seen in AT_3, AT_5, around Devprayag, Srinagar, Nagrosu, Gauchar, Karanprayag and Nandprayag in the terraces suggest the presence of some fossiliferous horizon of quartzite in the headwords' ends of Alaknanda. It appears that these horizons were actively subjected to erosion subsequent to recedes of glacier in post Pleistocene time.

The sediments of these terraces are mostly similar in composition to the terraces of glacial and fluvio-glacial origin, but are characterized by higher order of sphericity, roundness, sorting, imbrications pattern and sedimentary

features, viz. graded bedding, cross bedding, both planner and tough type, lamination, minor ripples, cut and fill features and cyclic sedimentation typically of fluvial domain.

The higher order of sphericity, roundness, sorting of these sediments indicate their derivation from the distant and mixed provenances during the different phases of sedimentation in the Quaternary times.

The fine sediment of these terraces consist of sand of different grade and shade such as smoky micaceous, coarse to fine sand; light to dark yellow coarse to fine sand and silt; light to dark maroon silt and clay with subordinate amount of sand; light brown sand with abundant granules of quartz, feldspar and mica flakes. These sediments, in general, are embedded with the coarse rock clastic comprising the various terrace horizons. In Alaknanda, valley at very few places, e.g. around Bamoth, Nagrosu, Ratura, Lameri Gulab Rai, independent beds of coarse to fine sand ranging from 2.5 m to 10 m are noticed. In this area, the sand of various grade and shade comprise of different sub units of variable thickness in alternation and display sedimentary features of minor scale, viz. lamination graded lamination, minor ripples and entrapped small lenses of fine sand mostly of cut and fill nature. (Plate No.5, 6, 7)

(The detailed description of river terraces is given in the subsequent head), (Plate No.8 Unit NoII).

Alluvial Plain :
The Alaknanda and its tributaries in the present area form the sinuous to meandering channel pattern as their relative ratio of channel length and valley do not exceed 1.5. As these rivers mostly descend through deep gorges and tight meander they comprise of very narrow strip of flood plain. At few places, however, the river is shallow forming flat bottom and relatively wide valleys e.g. around Srinagar, Gauchar, Umta, Langasu in Alaknanda, around Berhi, Bhaniyaro, Agastmuni, Tilwara in Mandakini, with the result that the flood plains have broaden out to an average width of 300 to 450 m.

These rivers exhibit swelling and pinching in their width at an alternate stretch all along the length across the Himalayan ranges, which appear to have been chiefly controlled by geologic as well as structural conditions and also by stream kinetics energy distribution in the fluvial domain of stream during sedimentation.

In general where the rivers are flowing across the "physically less competent and softer rocks such as phyllite the channel bars and channel braids are associated with active flood plain present day course of the channel and are mostly formed due to loss of bed gradient and under loading of the stream. The type development of these landforms in Alaknanda is observed around Srinagar, Nagrasu, Gauchar, Lanngasu and Nandprayag; where the channel bed is comparatively more flatten and valley is considerably wide.

These landforms generally comprise sub-rounded to well rounded boulders, cobbles, pebbles of quartzite, gneiss, granite, schist, phyllite, slate, limestone and the matrix of coarse to fine micaceous sand. These sediments appear to have been subjected to the repeated reworking as is evident by their highest order of sphericity and roundness in contrast to the other deposits in the valley,

Epigenetic Gorges and Fossil Valley in Aleksandra :
The Alaknanda River descends across the Himalayan in straight, sinuous pattern and its course is strongly controlled by structural elements, it has abandoned its original course at several places between Vishnuprayag and Devprayag and flows through newly curved out gorges. These new channel courses have been designated as epigenetic gorges (Heim and Gansser 1939) due to their lateral origin and the original abandoned courses have been termed fossil valley. Whereas Alaknanda has curved through the new epigenetic gorge, a fossil valley is also present on one of its bank and two are separated by a wedge or hump of ump of rocks of variable dimensions. These epigenetic gorges are formed perhaps due to superimposition of fluvial cycle of erosion on earlier glaciated valley, cyclic rejuvenation of Alaknanda associated with the different phases of up warping/climatic changes, sudden change in the Kinetics of the stream system and damming of the valley by landslides during the Quaternary times. In addition it appears that topography and structures have also played the vital role in forming the epigenetic gorges in Alaknanda valley.

In Alaknanda between Karanprayag and Srinaga at about ten places the epigenetic gorges have noticed. These occur near Karanprayag, Bamoth, Gharkot, Dharkot, Ratura, Trini, Uttiyasu, Kaliasour, Koteshwar and Srinagar and are described below: (Plate No.13).

Karanprayag :-
Karanprayag is situated at the confluence of Alaknanda and Pindar, about 170 kms. Upstream of Rishikesh. The present confluence of these rivers is at a point slightly upstream of the original one. Two fossil valleys have been noticed around the confluence, one of the right bank of Alkananda another on the left bank of Pindar. These abandoned courses are covered by the channel sediments comprising boulder, cobble pebble of quartzite, gneiss granite, schist, basics, slate in the matrix of sand, and silt. The present courses of these rivers have been occupied the epigenetic gorges. These are separated by the hump of in-situ rocks from the fossil valleys.

Bamoth :-
Around Bamoth about 2 km. upstream of Gauchar the Alaknanda takes its course through the straight and narrow epigenetic gorge leaving on the right bank an elongated abandoned segment of the channel course. These two are separated by linear wedge of in situ rocks comprising slate and basics. The gap of abandoned course is filled up by a sheet of recent sediments predominantly comprising of quartzite, gneiss, granite, schist, slate and basic of variable shape and size in the matrix of sand and silt. This abandoned course if noticed at the height of about 5 meters above the present day course of Alaknanda.

Gholtir:-
Near village Gholtir about 15 kms, downstream of the Karanprayag, Alaknanda flows through a epigenetic gorge and abandoned channel course may be seen on the right bank about 5 meters above the present day course of river. It is partly covered by sand and gravel and is separated from the epigenetic gorge by a small rock block rising from the river bed.

Dharkot: -
Around Dharkot two levels of abandoned courses are identified, one about 5 meters and another about 40 meters above the present day channel course of Alaknanda. The later is separated by the in situ rock from the epigenetic gorge forming a steep wall on the right bank of the river. The gap of abandoned courses between the rock wall and valley flank is filled up by thick sheet of light to dark yellow coarse to fine grained micaceous sand comprising subordinate amount of sub-rounded to rounded gravels of quartzite, gneiss, granite, schist and basic of variable shape and size. The sand bed measuring to about 5 m. in thickness embraces well preserved sedimentary structures viz. cross bedding, graded bedding, lamination, cross lamination, parting lineation and cut and fills features with in epigenetic gorge.

Ratura :-
Around Ratura about 5 kms. Upstream of Rudraprayag a prominent fossil valley is noticed on the left bank of Alaknanda. It is located about 50 m above the present day channel course of river. It is separated from the epi-genetic gorge by a small isolated in situ rock block of quartzite rising from the valley floor. The gap of fossil valley is occupied by coarse to fine grained light to dark yellow, micaceous sand and silt. The sand deposits display well preserved sedimentary structure viz.cross bedding both planar and trough type, graded bedding, lamination and cross lamination and cut and fill feature.

Lameri :-
Around Lameri about 2 kus. Upstream of Rudraprayag Alaknanda takes its course through deep and tight gorge and an abandoned course which lie on the right bank of the river under the recent sediments. Slightly upstream near the village Trini another old course of Channel has been noticed on the left bank, which is separated from the epigenetic gorge by an irregular and elongated wedge of the country rock. These abandoned courses are noticed at the height of about 40 and 10 meters above the present day course of river respectively. The levels of these courses roughly coincide with the second and fourth terrace (AT1 and AT4) and appear to have occupied/ followed by the river during the third and fourth stages of the valley development.

The relative distribution of terraces, rock cut benches, scar lines, fossil valleys and epigenetic gorges in the area indicating that possibly Alaknanda had adjusted its base level along some weaker planes in this area during the upraise of headwords ends of Alaknanda on the Quaternary time.

Uttiyasu :-
About 5 kms downstream of Rudraprayag near village Uttiyasu, Alaknanda flows through an epigenetic gorge. The old course left buried under the channel sediments at an elevation of about 40 m above the present day course of

river. It is separated from the epigenetic gorge by both terrace sediments and in situ block of country rock. The regional correlation of terraces and fossil valley indicates that this abandoned course near Uttiyasu was being followed by Alaknanda during the third stage of valley development in Quaternary times.

Kaliyasour :-
Around Kaliyasour the Alaknanda flows through the epigenetic gorge and old fossil valley is seen at the left bank of the river. This valley is occupied by sub-rounded to well rounded boulders, cobbles, pebbles of quartzite, granite, gneiss, schist, slate, phyllite and sand. It is separated from the epigenetic gorge by a hump of in situ country rock. Another old course is noticed about 1 km upstream of Kaliyasour about 5 m above the present day channel course of river. It is mostly covered by gravel and sand,

Koteshwar: -
About 3 kms upstream of Srinagar, Alaknanda makes a tight meandering loops and flows through an epigenetic gorge. Two abandoned courses of river have been identified at different elevation across the nose of sharp meandering loop; one on the right bank and another on the left bank at the elevation of about 35 and 15 meters above the channel course respectively. These abandoned courses are occupied by the recent gravel and sand, and separated from the epigenetic gorge by a wedge of country rock. In the adjacent area on the right bank a steep rock-cut bench is noticed, which is capped by a veneer of recent sediments. The disposition of fossil valley, a rock-cut bench, association of large number of boulders with the terraces indicate that river had abandoned its earlier courses mainly due to reactivation in stream Kinetics/energy conditions during the sedimentation in recent past. (Plate No.1)

Geomorphic Features And Landform Elements:
The various geomorphic landform elements and features identified in the area are described below:

Erosional Terrace/Rock Cut Terrace:
These are rock cut benches of Quartzite, Phyllite slate which are generally overlain by a thin veneer of river burned sediments consisting of sub-rounded to well rounded rock gravel, with sand. These are essentially erosional terraces and were formed by river during the erosional phase with a view to attain the base level of the river system. In general these terraces are elongated in shape and have an average height of about 6.5 m above the river bed. The prominent rock cut terraces are identified around Pipalkoti, Chamoli, Nandaprayag, Langasu, Karanprayag, Gauchar, Ratura, Rund raprayag, Kaliyasaur and Medanpur.

Point Bar:
The point bar is channel land form element and generally formed on the convex side of the meander loop of the river, with the dimension ranging from 850 x 250 mts to 1000 x 150 mts in Alaknanda 350 x 200 to 150 x 50 m in Mandakini, 150 x100 to 80 x30 m in Pindar 150 x 100 to 100 x 50 m.

The prominent development of point bar is seen around Chamoli, Karanprayag, Gauchar, Langasu, Kallyasour, Srinagar, Kirtinagar, in Alaknanda, Theralli, Kulsara, Narayanbagard, Simli in the Pindar valley. This landform consist of sub rounded to well rounded boulder, cobble, pebble of quartzite, gneiss, granite slate, phyllite basics in the matrix of very coarse to fine sand.

Channel bar:
The channel bars are mainly identified within the active channel of Alaknanda and its tributaries. These landform elements are mostly lensoid, elliptical in shape with average dimension ranging from 100 x 65 m. The channel bar predominantly consists of very coarse to fine sand and rock gravel. The prominent channel bars are identified around Nandaprayag, , Langasu, Gauchar, Nagrasu and Srinagar.

Stabilized channel bar :
The stabilized channel bars are identified around Langasu, Srinagar and Tilwar associated with the active channel coarse of Alaknanda and Mandakini in the area under study. These are mostly elliptical and lensoid in shape consisting of mainly coarse to fine sand and rock pebbles.

Alluvial Fan:
Alluvial Fan is a body of stream deposits whose surface approximates a segment of a cone that radiates down slope from the point where the stream leaves a mountainous area. Alluvial fans have greatly diverse sizes, slopes, types of

deposits and source area characteristics. They are most wide spread in the drier parts of the world but have been studied in humid regions such as Japan, the 'Himalayan mountain (Drew 1873) and Canada (Winder 1965) and in the Arctic regions (Hoppe and Ekman 1964, Legget and others 1966).

The Alluvial fans in the present area of study identified are of various shape and dimension. A prominent alluvial fan occupying an area about 1.85 sq km is seen around Langasu. It is conical in shape and consists of hetrogenous and assorted assemblage of rock fragments of quartzite, slate basic in the matrix of very coarse to fine silt and clay. It is drained by radial net work of stream which have appreciably incised.

The conical fan forms the deep gullies and steep scarp across the head to the toe. The deposition of sediments is still active in the lower part by the net work streams draining across this alluvial fan.

Talus Cone:
The rock fragments found on slopes or at the foot of steep slopes and cliffs under conditions of sub polar or arid subtropical climates are variously referred to as Talus, scree or rock debris. The term talus is of French origin ("Slope") but employed in a special sense in geomorphology. There are various types of talus cones, (Sidney White, 1968) viz. rock fall talus, alluvial talus, Avalanche talus, creep and talus cone.

The talus cone is generally formed mainly by accumulation of rock debris through many small rock falls close to a mountain wall. The talus cone in the area under study identified around Damar in Mandakini valley. It is small talus cone and have occupied an area about 800 sq. m. The slope profile of talus is slightly curved and the inclination is between 40° to 45°. It consists of rock debris of quartzite, slate, basic in the matrix of silt and clay. The rock fabrics of talus cone are mostly heterogeneous in nature and show slight imbrications and rough orientation of longer axis down the slope, probably due to sliding of debri under gravity. Besides talus cones of cirque moraines are also seen in Joshimuth - Badrinath section in Alaknanda valley.

Fan Cut Terrace:
In the area the high level fans and older alluvial fans have been observed at several places in Alaknanda around Kaliyasour in Mandakini north west of Tilwara and in Attagad valley around Adibari besides these elements are commonly seen with small subsequent streams joins Alaknanda at various places. The fans occur as distinctly sloping surfaces with the master slope in the direction across the flow of main streams. These fans are formed of material derived mainly from local high relief areas having been brought and deposited by steeply sloped tributaries at their mouths. Periodic heavy discharge in these tributaries bring greater sediment load of higher sizes while in the lean periods the sediments are relatively finer so that a pseudo stratification of coarser and finer sediments occurs in cross section, the bands appear to have a slope of 10° or more towards the river parallel to and slightly fanning away from the parent streams, which deposited them. These fans, when incised and left over in the form of sloping benches constitute the fan cut terraces.

Abandoned channel/epigenetic gorges:
The Alaknanda,and Mandakini at several places have carved their courses through epigenetic gorges and left its earlier courses on the bank as fossil valleys. These Two are separated by either a wedge of rock, or river borne sediments. These gorges were formed perhaps due to superimposition of fluvial cycle on earlier glaciated valley, sudden change in stream kinetics, or damming of the valley by mass wasting processes. or by dumping of sediment load due to change of stream kinetics. The change in the stream kinetic appears to important factor in forming the abandoned channel and epigenetic gorges in the area. The prominent abandoned courses and epigenetic gorges are identified around Karanprayag, Bamoth, Gholtir, Dharkot, Ratura, lameri, Uttiyasu, Kaliyasour, Rudraprayag, Koteshwar in the Alaknanda valley and around Tilwara in Mandakini valley.

Break in slope
In rugged and highly undulating relief area slopes may take variety of forms. A geometrical terminology is given by Saviger (1956), according to him slopes may consist of elements which are can cave upward (angle constantly decreasing down slope) convex upward (angle constantly decreasing down slope) straight or rectilinear (unchanging angle) and complex (great variation of slope in a short distance) changes from one type of profile to another are termed break in slope.

The area of study display relief variation from 550 m to 3000 m and form the highly undulating and rugged terrain of Lessar and Central Himalayan mountainous tract of complex nature where the variation in slope profile is obvious. The conspicuous break in slope are identified in the present area of study are associated with the faults, lineaments, mass wasting processes glacial and peri-glacial areas due to differential weathering of landscape.

Scar lines :
The Scar lines are linear and curvilinear features which are conspicuously associated with the valley flanks of Alaknanda and its tributaries in the area under study. These lines are identified at various height and are correlatable with the prominent terrace level therefore indicate the level at which the river once flowed in the past. The prominent Scar lines are identified around Pipalkoti, Chamoli, Karanprayag, Ratura, Rudraprayag, Kaliyasour, Srinagar and Deoprayag in Alaknanda Tilwar, Rampur and Medanpur in Mandakini valley.

Landslides:
In every slope gravity produced shearing stresses exist which increase with slope inclination and height and with the unit weight of slope forming material. Within the surface zone, the processes of freezing and thawing, Shrinkage and swelling and thermal expansion and contraction produce further shearing stresses. In response of the slope to these imposed stresses is controlled by resistance to shear deformation currently exhibited by its component material, its closely dependent on the pressures exerted by ground water which generally occupies the soil pores, very slow largely irreversible deformations termed creap begins as soon as the "critical" strength is exceeded, which may be considerably lower than the strength at which the shear failure occurs (Haefelt 1953). As imposed stress approaches the average shear strength the rate of creep increases until eventually some form of the relatively rapid failure takes place to which the genetic term landslide is applied (Terzaghi 1950). The prominent landslides identified in Alaknanda, Bhagirathi and Pindar valleys in the area are described in detailed under the head of mass wasting. The other various forms of mass movement identified in the area are described earlier.

Rock fall Debri fall :
The Rock falls comprise the more or less free descent of masses of soil or rock of any size from steep slopes or cliffs. As Rapp (1961) has emphasized, on the slope steep enough to be subject to falls, no significant protective mantle of rock waste can accumulate and mass movement can proceed as fast as weathering and disintegration of the parent mass permits.

The Rock fall and Debri fall are characterized by frequently protected phase of progressive separation of mass from its parent cliff which eventually leads to its abrupt collapse. The separation is effected initially by the growth of tension cracks, the final release of rock mass commonly occurs through shear failure of the root of the mass. These failures are confined to surface zone of rocks, in which the effects of pressure release and is of seasonal variation in temperature and cliff water pressure are most significant. In the present area of study in Garhwal Himalayas well marked annual peak of rock fall intensity in the spring suggest thawing following frost bursting to be relevant mechanism. The most of Rock fall and Debri fall mass wasting processes are conspicuously associated with the old abandoned cirques, active glaciated areas and peri-glacial area beyond average height of about 2800 m.

Scree and Scree slopes:
The rock fragments found on the slopes or at the foot of steep slopes and cliffs under conditions of sub-polar or arid sub-tropical climates are variously referred to as talus, scree or rock debris. In the area under study the scree deposits/ scree slopes are identified in Alaknanda around langasu, Bamoth and Nandaprayag in Mandakini north of Rudraprayag, around Rampur, in Pindar around Simli and Karanprayag. These elements are mostly elongated in shape and restricted along the outer edges of valley flanks. The scree predominantly consists of sub-angular rock fragments of quartzite, phyllite slates, limestone and basic in the matrix of clay these rock clastics are highly assorted and are heterogeneous in texture. The average thickness of these deposits is about 6.5 m.

Retreating scrap:
The Retreating scraps are structural scarps and are mostly controlled by joints or faults. These scarps later are associated with rock fall and debri fall. The general trend of these scarps are NW-SE, and N-S among these NW-SE is relative most prevailed and coincide with major structural trend of Himalaya.

Crest line sharp Major:
These crest lines forms the major water divide in the area. These lines comprised of both asymmetric and symmetric ridges of quartzite, slates, phyllites basic, gneiss, granite and schist having steep, moderate and gentle slope. The height of these lines varies from 2200 m to 2778 m above the mean sea level and average height is 2310 m.

Crest line sharp minor:
These crest lines comprise of both asymmetric and symmetric ridges of quartzite, granite and geniss having steep to gentle slope. These lines form sub-water divide with the basin. The intervening part of such lines is drained by subsequent, consequent and consequent streams. The height of these lines varies 1850 to2250 mts and average height is 2035 m.

Crest line rounded major:
These line consist of asymmetric to symmetric ridges of phyllites, slates and gneiss which have been subjected to varying degree of dissection in response to both structure and lithology. These crest lines have developed two types of erosional slope which are generally consequent and obsequent in nature. The height of these crest lines ranges from 1950 to 2200 m above the mean sea level and average height 1s 2140 m. These crest lines form the sub-basin which are drained by mostly sub parallel to parallel streams.

Crest line rounded minor
The crest line rounded minor are mostly developed on the asymmetric and symmetric of phyllites, slates gneiss and limestone having moderate and gentle slope. These slopes are drained by sub-parallel to parallel streams. The average height of these lines is about 1500 m above mean sea level. The other geomorphic features and landform elements recognized are cirque moraines, land slide scars, old stabilized landslides, scarp associated with rock fall, debri fall, V-shaped valley, U-shaped valley, flat bottomed valley, water fall, spring and nick points.

Abandoned cirque:
Cirques are commonly described as armchair shaped hollows possessing three distinctive elements, a steep nearly vertical headwall, a concave floor meeting the headwall in sharp break of slope and a lip or threshold at the entrance which may be of bed rock, glacial moraine or both. The threshold may impound a cirque lake or tarn.

In the present area of study embraces mainly the abandoned cirques which were once occupied by glaciers and were abandoned due to glacier recedes and shift of snow line related with the climatic changes in the region. These abandoned cirques are of various shapes and size such semicircular semi-elliptical and elongated. With an average dimension varying from 1500 x 1000 m to 6000 x 6000 m. The most of these cirques are barren barring few which consist of thin cover of loose debris, consisting' heterogamous assemblage of various rock fragments. The prominent cirques are identified north of Gopeshwar, east of Pipalkoti, east and north east of Nandaprayag, north and west of Nauli at an average elevation of about 2500 m above the mean sea level.

Arêtes :
The Arêtes are generally asymmetrical and symmetrical and both linear and curvilinear sharp ridges, which make the glaciers divide between various cirques. The slopes of Arêtes are moderate gentle to steep, the southern slopes are comparatively steeper than northern slope. The prominent Aretes are recognized around Gopeshwar, north east of Nandaprayag. Pipalkati and around Nauli in the vicinity of occurrence of abandoned cirques.

Threshold:
The Threshold is lip of cirque at the entrance which may be of bed rock, glacial moraine or both. The threshold may impound a cirque lake or tarn. The threshold in the area of study are narrow and both symmetrical and asymmetrical in nature and have developed mostly on bed rock. The width of these elements varies from 100 m - 350 m and average width is 243 m and mostly developed on the bed rock. These are devoid of any lake or tarn.

Horn Peak:
These are isolated peak or Horn developed on the arêtes due to progressive expansion of neighboring cirques. The prominent Horn Peakare in north of Gapeshwar and north- east of Nauli.

Glacial lake:
In the area under study two prominent lakes are identified viz. Diwar Tal north of Gopeshwar and Tark Tal, in the catchment of Berhi-Ganga. The dimension of these two lakes is about 50x75 m and 85x125 m respectively. These lakes contain fresh water which is use for domestic purposes locally. (Plate No.1)

Conclusionn:-

The Geological and Geomorphological study in Upper Ganga basin has been attempted in parts of de Uttarkashi,Chamoli, Pauri and Tehri districts an area of 10000 Sq.kms in parts of QA sheet 53Jand 53 N on 1:50000 scale of Garhwal Himalaya U.P; presently known as Uttrakhand State of Union of India. Out of total area of study, an area about 3500 sq.Kms has been selected for detailed Geological, Geomorphological and Sedimentological study.

The area of Upper Ganga basin consisting ofdrainage net of Alaknanda,Bhagirathi,Bhilangna, Nandakini, Mandakini, Pindar, Dhauli- Ganga Bal- Ganga , Madhmeshwar Ganga and Berhi Ganga. The Alaknanda ebraces and and chracterised by six fluvial terraces besides glacial and Fluvial terraces followed by Bhagirathi with five terraces , Bhilangna Nandakini four terraces Mandakini /Pindar/Dhauli-Ganga /Balganga three terraces , Madhmshwar Ganga two terraces and Bberhi Ganga one terrace besides Glacia , and Fluvial terraces amidst these Alaknanda is trunk stream and others are tributaries. The area genetically comprised of terraces of three domains, viz. Glacial, Fluvio-glacia and Fluvial which represent distinct environment of sedimentation of Pleistocene, late Pleistocene and Holocene time during Quaternary period. The Glacial terraces are identified at an average elevation of 1150 m above MSL, the fluvio-glacial terraces at an average elevation of 975m above MSL and Fluvial terraces at an average elevation between 650 to 900 m above MSL.

Geomorphologically the area is divided in to seven geomorphic units viz High relief formerly glaciated area,Structural hills, Denudational hills, Area of mass wasting, High level dissected fans, river Terraces and Present day flood plain of Alaknanda and its tributaries . These units area developed in response to lithology to erosional land depositional activities and tectonic in which they are embedded. Each unit is characterized by drainage, diagnostic geomorphic landform elements and features, photo charcters and morphogenetic expression. The other geomorphic features and elements identified in the area are point bar, channel bar, alluvial fans ,talus cone , rock cut terraces fan cut terraces , abandoned channel ,epigenetic gorges, strand lines landslides ,rock fall scree and scree slope, retreating scarp, abandoned cirque, arêtes, threshold, horn peak and glacial lake.

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