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RESEARCH ARTICLE

EVOLUTION OF FLUVIAL TERRACES OF ALAKNANDA AND ITS TRIBUTARIES AND IMPRINTS OF NEOTECTONISAM IN UPPER GANGA BASIN, GARHWAL HIMALAYA, PARTS OF CHAMOLI TEHRI UTTAKASHI & PAURI DISTRICT UTTAR PRADESH (UTTRARKHAND) INDIA

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Abstract

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The Geomorphological study in in Alaknanda and its tributaries Ganga basin Garhwal Himalya parts of Chamoli Tehri Uttarkashiand Pauri district Uttar Pradesh (Uttrarkhand with special reference to fluvial terraces has been studied . An area about 10000 Sq.kms in parts of QA sheet 53Jand 53 N on 1:1000000/ 1:50000 scale of has been covered. The area of Upper Ganga basin genetically comprised of terraces of three domains, viz. glacial, fluvio-glacial 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 m.s.l, the fluvio-glacial terraces at an average elevation of 975m above m.s.l, and fluvial terraces at an average elevation between 650 to 900 m above m.s.l, The area of Upper Ganga basin consists of Alaknanda,Bhagirathi,Bhilangna, Nandakini, Mandakini, Pindar, Dhauli- Ganga Bal- Ganga , Madhmeshwar Ganga and Berhi Ganga. Amidst these Alaknnda is trunk stream and other are tributaries. The Alaknanda is chracterised by six 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 terraces. The Badrinath temple is situated in glaciated trough valley of Alaknanda, which comprise of, four levels of the glacial terraces (lateral moraine), cirque moraine on mountain flanks and the terminal moraine at the base of valley. whereas Kedarnath in the upstream of Mandakini, where number of well developed cirques were identified on high mountain, 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 Kedarnath temple is situated in glaciated trough valley on quaternary platform formed by coalescing of cirque, lateral moraine and terminal moraine. The-Himalayan thrust like Central thrust Srinagar thrust,, Alaknanda fault, Tons thrust show flattening dip suggesting that they lie at comparatively at shallow depth at short distance, down dip from their out crops, recent movements

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along the trace of these faults /thrust are not of high and longer magnitude but have considerably affected Quaternary terraces of glacial, fluvio-glacial and fluvial domain of Alaknanda and its tributaries. Beside drainage, river bed profile, landscape architect and over all morphogenetic expression of the area bears the impact of tectonic activity. The imprints of neotectonisam associated in the area indicate that these thrust /faults are active and have posed tectano-ecological problems, bears signatures of sinking of the area, mass wasting activities and neosiemic hazards. The study revealed that there is sharp curvilinear break in morphogenetic expression of the area In North of Wazri in Jamuna valley, North of Uttarkashi in Bhagirathi valley, around Tugnath and Chamoli and South of Joshimuth in Alaknanda valley, which appears to be due to horizontal movement of a sub - tectonic plates towards south, which is causative factor in dislocation in tectonic ecology of the area, it is matter of serious concerned and needs further attention.

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Introduction:-

The Geological and Geomorphological study in Upper Ganga basin has been attempted in parts of Uttarkashi,Chamoli, Pauri and Tehri districts, an area of 10000 Sq.kms in parts of QA sheet 53J and 53 N on 1:100000/ 1:50000 scale has bben covered in Garhwal Himalaya U.P; presently known as Uttrakhand State of Union of India.

The area of study is approachable via Dehradun and Rishiksh which are nearest rail heads of Northern Railway. 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 kilometers from Rishikesh on state high way No 53 connecting Rishikesh Tehri Uttarkashi Gangotri.This road runs along Bhagirathi River between Tehri and Gangotri, it bifurcates at Dharasu and connects Bhagirathi valley to Yamuna valley crossing the water divide at Ravi Pass. In addition to these there are all weather roads which connect 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 Ganga and Berhi Ganga. Amidst these Alaknnda is trunk stream and other are tributaries, amidst these Alaknanda is trunk stream and other are tributaries. These streams emerge from different glaciers in Himalaya descend 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 (1972),Dubey (1974a) , Shukla Khan & Dubey (1974) Khan (1972-73) Khan (1974), Khan et.al (1974-75) Sinha & Khan (1975) ,Sinha & Khan (1975-76), Dubey (1974) Sinha & Khan (1976) Khan (1981), Khan (1987) have carried out geological and Geomorphological studies in parts of Alaknanda,Bhagirathi,Bhilangna, Nandakini, Mandakini, Pindar, Dhauli- Ganga Bal- Ganga , Madhmeshwar Ganga and Berhi Ganga. Amidst these Alaknnda is trunk stream and other is tributaries.

Present Work

The present paper is an attempt to trace integrated picture of evolution, of fluvial terrace sand their stratigraphy, their correlation in Upper 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 present shape to the area., Khan,

(1975) and Khan et al, 1981).The Fluvial terraces of Alaknanda and its tributaries are developed and evolved in response to tectonic changes and cyclic uplift of watershed region of upper Ganga during Quaternary times, (Khan 1987) The glacial, inter glacial and post glacial climatic conditions, have also played the vital role in morphogenetic shaping of present day complex. (Khan 1981). On the merits of evolution of fluvial terraces the sequential order of valley development in upper Ganga basin is established (Khan 1987).

Geomorphic Evolution of Fluvial Terraces in Upper Ganga Basin,Stratigraphic and chronological sequence of Quaternary deposit is given in table below:

Table No. 1:- 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 & its tributaries.	Sub-Angular to angular boulder, cobble, pebble of gneiss, granite, quartzite, granite, quartzite, biotite, 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 No. 2:- Stratigraphy Of Quaternary Terraces In Upper Ganga Basin, Garhwal Himalaya U.P.

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 of Berhi Ganga, Madhmeshwar Ganga, Balganga, Man-dakini Flurio-glacial environment

Pindar, Dhauli Ganga, Bhilangna, Nandakini, Bhagirathi and Alaknanda

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

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 aggradations 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, , Khan et.al.(1985).

These terraces are comprised of surrounded 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.

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 caustic 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 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.

The Fluvial Terraces Of Alaknanda Valley:

The Alaknanda, the trunk stream of Ganga System forms at Vishnuprayag by two tributaries, viz. Vishnu Ganga and Duauli Ganga rising from snowy peaks north of Badrinath and Niti at average elevation of 3,897 m and 5,330 m respectively in Central Himalayas.. The river descends in straight/sinuous to meandering channel pattern through the deep gorges across the Himalayan ranges, with sinuosity index ranging from 1.95 to 2.6 for meandering segment. It is joined by numerous other tributaries in its traverse in Himalaya till it finally debouches in the intermountain Doon valley at Rishikesh. The important tributaries joining Alaknanda between Vishnuprayag and Rishikesh are, Berhi Ganga at Chinka, Nandakini at Nandaprayag, Pindar at Karanprayag, Mandakini at Rudraprayag and Bhagirathi at Deoprayag, downstream of Deoprayag it is known as Ganga.

The Alaknanda all along its length across the Himalayas has characteristically NE-SW course except the swing between Karprayag and Rudraprayag and Srinagar Janesu, where it drains in WNW-ESE and NW-SE direction respectively. The other tributaries in the north eastern part of the basin viz. Berhi Ganga, Nandakini and Pindar and Patal Ganga have, however, the conspicuous NW-SE course and join Alaknanda at sharp angle. The course of Alaknanda appears to have been constantly maintained its course, inspite of rise of Himalaya as is evident from entrenched meanders, deep gorges, steep cliffs and peaks which is suggestive of its antecedent nature.

The courses of tributaries appear to have been guided by NW-SE trending lineaments, which are mostly sympathetic in nature and their trends coincide with the major NW-SE structural trends of the Himalaya. The Alaknanda all along its length displays swelling and pinching nature in its width and its flanks are occupied by terraces of glacial, fluvio-glacial and fluvial origin. In the glaciated and Peri-glacial terrain it passes through straight segments with tight meanders and the average width of the valley does not exceed 225 m. In the fluvio-glacial and fluvial part of the valley average width varies from 190 to 210 m and the widest part is of the order ranging from 230 to 245 are seen around Langesu, Gauchar and Srinagar.

The Alaknanda has formed six prominent regional terraces in the valley. These have been designated as AT0, to AT6. The AT0, being the low level surface above the present day course of the river being a part of active flood plain. The AT1, being the youngest and AT6, being the oldest terrace in the area. Each of these terraces is separated by the scarp both of linear and curvilinear in nature facing towards river. These terraces are both erosional and depositional in nature and display divergence and convergence in their relative disposition.

The erosional terraces are generally seen as isolated pockets and lenses resting over the country rocks along the higher part of the valley flanks, representing the former levels of valley floors. In general these terraces are very ill preserved and have very few matched equivalent in the valley. The occurrences of these terraces and associated features in the higher parts of valley indicate the rigorous and abrupt incision of valley floors due to relatively rapid and sudden uplift of watershed region of Alaknanda during the early Holocene times.

The depositional terraces are widely developed and have occupied the larger area in the valley around Srinagar Kaliyasaur, Kirtinagar Pharases, Dungri, Gulab Rai, Nagresu, Gauchar and Langasu, Sunala and characteristically found to be restricted within the meander of Alaknanda. These are extensively used both for inhabitation and cultivation in the valley. These are characterized by the deposition sedimentary features such as graded bedding cross bedding lamination, graded lamination, minor ripples, cut and fill features and poly cyclic sedimentation typically of wide flood plain environments and both migrating as well as incisive system of the channel of fluvial domain predominantly of depositional in nature.

The complete sequence of terraces in the valley is seen at very few places viz. around Srinagar, Koteshwar, Rudraprayag, Nagrasu and Gauchar which give almost the complete account of tectonic and climatic changes in the area. Whereas at other places one two or three terraces are preserved and many other have been eroded away. This therefore, indicates incisive as well as rapid migrating nature of the stream. These terraces are both paired and unpaired and display convergence and divergence in their relative disposition. The divergence and pairing in general is seen in the older terraces viz. AT6, AT5, and AT4, whereas the younger terraces viz. AT1, AT2 and AT3, display convergent in their disposition and mostly remained unpaired. The divergence and pairing in the older terraces indicate the abrupt and sudden incision of the valley floor due to relatively sudden upraise of head ward ends of the Alaknanda and consequent climatic changes, in the early Holocene times. The convergence and un-pairing in younger terraces, on the contrary, indicate decrease in rate of uplift and long interval climatic change towards the later phases of sedimentation in the valley. The pairing, un-pairing and relative disposition of terraces as whole in Alaknanda suggests the constant and steady decrease in rate of uplift in Himalaya from early to late Holocene time. Khan (2018)

In Alaknanda valley, these terrace (AT_3, $AT_{5)}$ are characterized by the association of fossiliferous boulder, cobble, pebble of quartzite with the luxuriant assemblage of productus, spirifer and other species of Brachiopods and Mullose group typically of permo-carboniferous age. Although these rock constituents are mostly confined in these terraces and noticed around Devprayag, Srinagar, Nagrosu, Gauchar, Karanprayag and Nandprayag ,suggest the presence of some fossiliferous horizon of quartzite in the catchment area of Alaknanda which actually been subjected to extensive erosion during third and fifth phase of erosion . subsequent to recede of glacier in post Pleistocene time

The average total thickness of fluvial terraces in Alaknanda is 118 m. The highest terrace i.e. AT6 1s noticed at an average elevation of 795 m from m.s.l. and 150 m from the present day course of the river. The average thickness of individual terrace is 16.25 m., 22.25 m., and 27.22 m., 25 m., 21.25 m., 15 m., respectively. In the upstream areas, the thickness of these terraces is constantly reduced and ultimately the profile of these terraces pinches out against the higher terraces of fluvio-glacial origin.

The scarps separating the different terraces in the valley are generally of linear and curvilinear in nature. The scarps of older terraces in general are intensively dissected by the minor rills and gullies and extended gullies. The degree of maturity is relatively high in these terraces in contrast to younger ones and scarps of these terraces are mostly more stabilized, though at places the convex slopes along the scarps are developed due to debris slides.

The terraces developed in Alaknanda are in general rectangular, semi-circular to circular and cuspate in shape. Each of this type is related to the separate genetic processes. Among these, the semi-circular is most common in the valley, which are related to the short interval meander of channel and formed due to enhanced energy conditions of the channel, associated with the increasing discharge and low gradient. Such terraces are observed around Nandaprayag, Gauchar, Papresu, Dhari-Khaliyesour, These are in general non-cyclic terraces. The elongated rectangular non-cyclic and cyclic terraces in the valley are observed around Shrinagar, Nagresu, Gauchar, Bamoth and Langesu. The former ones were formed by a combined processes of lateral coalescences and unidirectional sudden shift of straight segment of channel and subsequent incision whereas the later one, due to abrupt reactivation in energy condition due to sudden climatic changes and subsequent adjustment of base level of channel by incision of valley floor. The semi-circular to circular and cuspate terraces is related to the meander processes lateral shift of channel and ingrown incision. The point bar development in such processes is often noticed in the slip of slope of channel meander loop and the terraces occur as slices within the periphery of meander, separated by small scarps relatively of small magnitude. The ill preserved circular terraces are noticed around the confluences of Alaknanda, with Bhagirathi around Devprayag; Alaknanda with Mandakini around Rudraprayag; and Nandakini around Nandaprayag, which were formed by the initial erosion and subsequent deposition during the inception of these major tributaries.

The cuspate terraces revealing a dip of 2° to 3° are formed by incision of several loops at different elevation on the same side of valley. These suggest multiple rejuvenation through the micro episodic change in discharge and micro pulsation of unwrapping in head ward ends of Alaksandra (Khan, 1974).

The detail description of salient features of Alaknanda terrances in type localities have been tabulated in Table No11

Fluvial Terraces Of Bhagirathi Valley:

The Bhagirathi is the major tributary of Alaknanda. It rises from Gangotri glacier north of Uttarkashi around Gaumukh in the Central Himalaya at an elevation of about 3665 m and joins Alaknanda at Deoprayag the river descends in sinuous to meandering with an average sinuosity index of order of 1.30. The river all along the length of 160 km has formed the terraces of three domains Viz. glacial fluvio-glacial and fluvial. The fluvial domain comprised of five major terraces which are time equivalent to the five younger terraces of Alaknanda, the trunk stream of Ganga system. These terraces are designated BT1, to BT5. The BT1, is youngest terrace and BT5, being the oldest in the valley. These terraces are mostly fill and cut type and are both erosional and depositional in nature. The older terraces BT3 to BT5, are elongated, rectangular in shape and have paired equivalents on both the flanks of valleys, whereas the younger terraces BT1, and BT2 are semi circular and crescent in shape non-cyclic in nature and are restricted within the meander of Bhagirathi.

The type development of these terraces is seen at very few places in the valley Viz. Uttarkashi, Dunda, Chinyalisaur Chamb, Tehri, whereas other places such as Sarot Seansu and Nagor one or two levels of terraces were seen, which appears to be due to exposure of the area to extensive post depositional activities, reworking of terrace sediments by subsequent streams developed on the slopes of valley and extensive lateral cutting by Bhagirathi. The total average thickness of these terraces in the val1ey is 36 m. The average relative thickness of these terraces in Uttarkashi and Tehri section is 6.5, and 5 m respectively.

The detailed salient features of Bhagirathi terraces have been tabulated in Table No12

Fluvial Terraces Of Bhilang Na Valley:

The Bhilangna is a tributary of Bhagirathi. It originates from ice clad peaks of Central Himalaya at an elevation of about 3200 m and joins Bhagirathi at Tehri. It display sinuous to meandering channel pattern all along its course of 75 km and embraces the terraces of three regimes, viz. glacial, fluvio-glacial and fluvial, deposited in three distinct environments during the Quaternary times.

The Fluvial terraces are designated as BHT1, to BHT4 the BT1, is being the youngest terrace and BHT4, is the oldest in the valley. These terraces are mostly deposition in nature and exhibit divergence and convergence in their relative disposition, the former is more conspicuous in older terraces BRT4 and BHT4, whereas the later in the younger terraces. The type development of these terraces in the valley is seen around Tehri, Dewal. Asena and Ghansali Dubey, (1972) Khan (1981). Khan (1974) (1975). The total average thickness of these terraces is about 55 m whereas the relative thickness is 16, 15, 18, 16 m respectively.

The salient features of Bhilangna terraces are tabulated in table No.13

The Fluvial Terraces Of Nandakini Valley:

The Nandakini, a tributary of Alaknanda, It rises in northeast of Sutal in the Central Himalaya at an elevation of about 3660 m from the snowy peak, descends down in sinuous to meandering pattern, with sinuosity, index ranging from 1.20 to 1.25. It also passes through the straight segment of the valley and tight meanders and joins Alaknanda at Nandaprayag. It comprises three distinct groups of terraces deposited entirely in different enrolments, viz. glacial, fluvio-glacial and fluvial. In the fluvial domain four prominent regional terraces in Nandakini have been identified which are time equivalent of the four younger terraces of Alaknanda the trunk stream and the Bhagirathi, Bhilangna, and other major tributaries of the Ganga system.

These Fluvial terraces are designated as NT1, NT2, NT3, and NT4, NT1 is the youngest and NT4 being the oldest in the valley, NT0 is the low surface of the present day flood plain of the stream. These terraces are both erosional and depositional in nature. The terraces NT4, and NT3, and have generally the divergent relation, whereas NT2 and NT1, convergent mutual relation as well as with NT0, the NT4 and NT3, are mostly cyclic in nature and NT1 non-cyclic and characteristically restricted within the meander of channel. The full sequence of terraces is very rarely preserved in the valley such as around Nandprayag, Rajwaki, whereas at other places one or two level of terraces are seen. It is possibly due to frequential lateral shift of the channel, extensive lateral cutting and subsequently repeated reworking of the terrace sediments in the environments of increasing discharge and steep gradient towards the later phase in the history of river sedimentation.

The top terrace NT4, is observed at an average elevation of 1100 m above m.s.l and 80 m from the present day course of the channel. The total thickness of fluvial terraces in the valley is 80 m whereas the average relative thickness of individual terraces 10, 23.50, 23.50 and 23.50 respectively.

The detailed description of salient features of Nandakini terraces are given in Table No.14.

The Fluvial Terraces Of Mandakini Valley:

The Mandakini rises from the Gangotri group of glaciers in the north of Sonprayag around Kedarnath at an elevation of 3562 m and mingle with Alaknanda at Rudraprayag. All along its length it has formed the stepped sequence of terraces of three distinct domains viz. glacial, fluvio-glacial and fluvial. In fluvial domain three prominent regional terraces have been identified which are designated as MT1, to MT3 and are time equivalent to the three terraces of Alaknanda and other tributaries. (Khan1981). These are polyclic depositional terraces and their wide development is seen around Barhi Bhatwari, Sauri, Agustmuni, Rampur and Tilwara. These terraces portrays divergent and convergent relation amidst each other and are generally semicircular, elongated, semi-circular to circular in shape and are both cyclic and non-cyclic in nature. These terraces the conspicuous embody sedimentary features such as graded bedding, cross bedding both planer and trough type, lamination, graded lamination, cut and fill features, around Agastmuni, Tilwara, Behri, Saurgarh, Sauri and Bhatwari.

The total average thickness of fluvial terraces in the valley between Kund Chatti and Rudraprayag is about 40 m. The highest terrace is observed at an average elevation of 810 m above m.s.l

The Salient features of these terraces are given in Table No.15

Fluvial Terraces Of Pindar Valley:

The Pindar rises from the glacier top on the east of Dhakkni Devi Glacier in Central Himalaya at an elevation of 3621 m. It traverses across the Himalayan ranges and descends down through steep gorges forming straight sinuous to meandering channel pattern and joins its trunk stream Alaknanda at Karanprayag.

The Pindar all along its major part of traverse maintains straight course, between Kheta and Dewal, it almost drains in WNW - ESE direction. At Dewal it takes an acute turn changing its course to NNE - SSW, which further down stream of Nandikesri again swings in WNW- ESE direction and maintains it upto Karanprayag, where it mingles with Alaknanda. In between Dewal and Nandikesri the course of Pindar appears to have been controlled by NNE - SSW trending fault, which up stream of Dewal also control the course of Kali Ganga a small tributary of the Pindar. All along its length it shows swelling and pinching in width, which varies from 500 to 680 m between Kheta and Dewal, 600 to 700 m between Dewal and Theralli, 500 to 650 between Theralli to Narayanbag and between Narayanbag to Nalgaon the stream passes through the straight segment of deep gorge, having steep sides of valley flanks and smallest average width is 260 m. Downstream of Nalgaon the width of valley broadens out to the range from 670 to 850 m..

In Pindar valley between Theralli and Simli and Karanprayag three prominent regional terraces have been identified. These are designated as PT0, to PT3. The PT0, being the low level terrace, PT1, being the youngest and PT3 being the oldest terrace in the valley (Khan, 1975). These terraces are correlated with the three younger terraces of Alaknanda and other tributaries.

These terraces are formed by combined and intermittent processes of aggradations and degradation associated with different phases of sedimentation of fluvial regime. The process is repeated thrice in the valley during the Holocene times.

The highest terrace is observed at an elevation of 830 m above m.s.l. and 60 m from the present course of channel. The total thickness of these terraces in the valley is 55.5 m whereas the average relative thickness of individual terrace is 15 , 20 and 20 m (PT_1, to PT_3) respectively.

The detailed salient features of Pindar terraces have been tabulated in Table No.16

Fluvial Terraces Of Dhauli Ganga

The Dhauli Ganga is a tributary of Alaknanda, it originates from glaciated top in the Central Himalaya in upstream of Dapoban and joins Vishnu Ganga, near Joshimukh and down the Vishnuprayag it is known as the Alaknanda. The river has, conspicuous straight sinuous to meandering course and descends down through the tight gorges with the steeply rising valley flanks. The river has formed three prominent fluvial terraces besides several channel and land form elements. These terraces are genetically both erosional and depositional in nature and have been designated as DGT1, to DGT3. The DGT_1, is being the youngest and DGT3 is oldest terrace. The total average thickness of these terraces is 24 m and relative average thickness of these terraces is 10, 8 and 6 m respectively

The salient features of these terraces in type area around Tapoban are tabulated in Table No.17

Fluvial Terraces Of Bal-Ganga

The Bal-Ganga is a small tributary of Bhilagna. It rises from the ice clad peak in the Central Himalaya southwest of Kedarnath. This stream has formed three prominent fluvial terraces, beside the glacial and fluvio-glacial terraces in the upper reaches which occur in the form of isolated and dissected caps. These fluvial terraces are mainly depositional in nature and are designated as BGT1, to BGT3, the BGT1, it is being the lowest and youngest terrace, whereas BGT3, the oldest terrace. The relative average thickness of these terraces is 5, 10 and 7 m respectively.

The salient features, shape and composition etc. are tabulated in the Table No.18

Fluvial Terraces Of Madhmeshwar Ganga:

The Madhmeshwar Ganga is a tributary of the Mandakini. The stream originates from glacier southwest of Kedarnath and joins Mandakini near Okhimukh. The stream has formed two prominent river terraces, each separated by scarp. These are depositional in nature and are fill and cut type. The shapes of these terraces are semi-circular, which is mostly restricted in the channel meander and non-cyclic in nature. These terraces are designated as MDT1, to MDT2, (Khan 1981) from younger to older terraces respectively. The relative thickness of these terraces is 12 and 8 m respectively.

The salient features showing, shape, slope, relative disposition and composition etc. are tabulated in Table No.19.

Fluvial Terraces Of Berhi-Ganga Valley

Berhi Ganga is a fault controlled small tributary of Alaknanda. It drains mostly the Garhwal Group of rocks and joins Alaknanda at Chinka. The river is so young that it has been able to develop only one terrace beside its present day flood plain and is designated as BRT_1, which indicates single phase of rejuvenation of the river. The terrace is localized within the meander of stream. This terrace is time equivalent to AT1 terrace of Alaknanda.

The salient features showing, shape, slope, relative disposition and composition etc. are tabulated in Table No.20

Imprints Of Neotectonisam And Neo- Seiesmic Events In Alaknanda And Its Tributaries

In Himalayas the occurrence of movements in recent times are naturally be expected, where mountain building activities have occurred recent past and mountains are “rather young”. However, in contrast to the characteristics organic movement of Tertiary and pre Tertiary periods, the movement taking place during Neogene and Quaternary period are slightly different nature what is as Cymatogeny (L.King 1950-68). These movements which have taken place along pre-existing lineaments /thrust/ faults, are small magnitutede but have perceptibly affected the Quaternary terraces, glacial moraines, talus, cones, alluvial fans, drainage, channel morphology land forms and landscape expression.

It has been found that thrusting movements have caused the pre- Tertiary and late Tertiary formation to ride over the Pleistocene deposits.Geomorphological and actual measurements, consequently demonstrate that many of Himalayan thrust is tectonically quite active. According to estimate (Krishnaswamy et.al 1970) the rate of creep movement along Nahan and Riasi and other thrust may be order of 1-2cm/year. Fithch (1970) computed the rate of seismic slip of Himalayan thrust at 5.8 cms / year. The measurement Sinvhalet.al (1973) shows that along the Krol thrust near Kalsi the present movement is 0.92 cms/year . There are reveling example throughout Himalayan front of the older rock riding over recent and sub recent alluvial or talus deposits.

The sub Himalayan thrust like Srinagr thrust show flattening dip suggesting that they would lie at comparatively at shallow depth at short distance, down dip from their out crops. The recent movements along the trace of these faults /thrust are not of longer magnitude but have considerably affected Quaternary terraces, other land form and morphogenetic expression, have formed the nick points in the stream bed draining the area, it is evident by the profile of river bed and terraces.Sinha and Khan (1975), have observed the displacement in terrace near Dewal in Bhilangna valley along the Srinagar thrust near Seansu . The wide terraces on left bank of Bhagirathi appear to be uplifted and sloping up stream appreciably. The movement of Srinagar thrust and Tons thrust which passes in close vicinity of the area have also affected the litho units of terrace section. The reverse plunge in cobble pebble in terrace section in tectonically active area are conspicuous features of neotectonism and indicate recent movement along thrust fault traversing the area.

The Srinagar thrust further up stream in Bhagirathi traverses around Nalupani and forms the tectonic boundary between Barahats and Simla slates. There is a marked difference in the topography on both side of the thrust .As per observation the Srinagar thrust is geologically is of recent age and presence of nick points at some of stream crossing the thrust explained is due to movements, consequent upon the release of strain accumulated along it,. Dhanota (1970) made attempt to correlate the epicenter of some of the earthquake that occurred in the region to seismic activity at different depth along the Srinagar thrust plane. However, available data and records indicate that Uttarkashi Earthquake (1991) and Chamoli Earthquake (1999) was of 6.8 magnitude respectively, besides many shocks of low magnitude are recorded in the area. It indicates that area is sensitive and movement has been taken place in this part of Himalaya in recent times, it is prone to Earthquake. Generally in case of thrust a slow creep movement seems to take place, in which accumulating strain energy is when gradually dissipated and affect land form elements and morphogenetic expression of landscape of the area. it indicates that area is sensitive and pron to Earthquake.

Alaknansda is trunk steam of Ganga system formed at Vishnuprayag by intermingling of two major streams viz Vishnuganga and Dhauli Ganga rising from snowy peaks north of Badrinath. The river descends in straight and sinuous to meandering channel pattern through the deep gorges across the Himalayan ranges with sinuosity index ranging 1.95 to 2.6 for meandering segments. It is joined by numerous other stream tributaries during its traverse across the Himalaya till it debouches in the plain.

The Alaknanda all along its length across the Himalaya has characteristically south western course, except the local swing between Karanpryag, Rudraprayag and Srinagar, where it drains in south east direction. The course of Alaknanda seems to have been controlled by weak planes fault/ lineament, the course has constantly maintained by Alaknanda inspite of rise of Himalaya. It is evident by the conspicuous association of epigenetic gorges, entrenched meanders incised straight segments of channel courses, stepped rock cut terraces, cyclic terraces, cut scars and strand lines along valley flanks. The major tributaries of Alaknanda have conspicuous south east course and join Alaknanda at an acute angle. The course of this stream has been guided NW-SE trending lineaments which are mostly sympathetic in nature and their trend coincides with the major NW-SE structural trends of Himalayas.

The terraces of Alaknanda are both cyclic and non-cyclic in nature and display convergence and divergence in their relative disposition in the valley. The divergence and pairing is distinctly seen in older terraces Viz. AT6, AT5, AT4, whereas the younger terrace AT1, AT2, AT3 display convergence in their disposition the former are cyclic whereas the later mostly remained non-cyclic in nature. The divergence and cyclic nature of the older terraces indicates the abrupt and sharp incision of valley floor due to relatively sudden uplift of watershed region of Alaknanda in early Holocene times Khan (1981). The convergence and non –cyclic nature of younger suggest the decrease rate of uplift and long period of climatic changes in the region. As whole the occurrence of terraces and their mutual and disposition in Alaknanda indicates the steady and constant decrease in rate of uplift in Himalaya from early to late Holocene time Khan (2018).

The terraces developed in Alaknnanda valley are in general rectangular; semis circular to circular and cuspate in shape, each of these types are related to separate genetic and tectonic process.

Among these the semi circular, which are related with short interval meander of the channel were formed due to enhanced energy condition of the channel associated with increasing discharge and low gradient, such terraces are observed around Nandaprayag, Gauchar, Nagrasu, and Dhari Kaliyasaur. These are generally non cyclic terraces and indicate lateral shift in channel due to differential up warping of different blocks of Himalaya. The elongated and rectangular on-cyclic and cyclic terraces in the valley are observed around Srinagar, Nagrasu, Gauchar, Bamoth and Langasu. The former one were formed by combine processes of lateral coalescences and unidirectional shift of the straight segment of channel and subsequent incision, where the later due abrupt activation in energy condition due to sudden uplift and subsequent adjustment of the base level of channel by incision of the valley floor.

The semis circular to circular and cuspate are related to the meander process, lateral shift of the channel and ingrown incision. The point bar development in such process is often noticed in slip of slope of channel meander, separated by small scarp relatively of small magnitude indicate the micro pulse of uplift in Himalayan towards later phases of terrace formation.

The cuspate revealing a dip of 2 to3 degree is formed by incision of several loops of different elevation on one side of the valley. It suggests multiple rejuvenation of the channel through micro-episodes of uplift in the head ward ends of Alaknanda during Quaternary time. These terraces are observed around Rudraprayag, Karnpryag, Srinagar and Gauchar in Alaknanda valley Khan (1981).

In upstream of Karanpryag in Alaknanda Valley around Utma and Thali tilt in river terraces of 3 to 5 degree towards North –East does recorded Khan (1981) .The sub litho units of these terraces comprise rock clastics of various shape and size in the matrix of sand and silt. It displays appreciable displacement and dislocation in their disposition in terraces section .The tilt in terraces block and associated characteristics of rock fabrics strongly suggest the recent movement in the area along some lineaments.

Khan (1981) recognized linear trench across the terraces in Alaknanda valley around Nagrasu, Gholtir, and west of Gauchar along the Alaknanda fault. This East-West trending fault deeply dissected the multiple sequence of terraces and developed truncated drainage of minor gullies of partly impersistent and internal nature. This fault seem to be active in this area as evident by shifting of the terrace block, active retreating terrace scarp, minor dislocation in stratified sand horizon, steep vertical incision in, active alluvial capping in the terraces along the valley flanks, and diverse imbrications pattern of rock fabrics along the straight segment of channel. The release of accumulated strain energy along the fault plane and subsequent reactivation of the fault has appreciably organized mass wasting processes in the linear order in the vicinity.

At several places between Deoprayag and Vishnuprayag the Alaknanda has abandoned its original course and flow through newly curved out gorges. Theses channel course are designated epigenetic gorges, Hem and Ganssar (1939) due to their lateral origin and original courses have been termed them as fossil valley Waltier (1962). However, Alaknanda have curved through the new epigenetic gorge, a fossil valley is also present on the one side of the bank and two are separated by a rock wedge of variable dimension. According to Khan (1981) theses epigenetic gorges in Alaknanda were formed by sudden rise of watershed area and consequent rejuvenation of stream to active the new base level, in changed kinenetic condition , discharge and bed slope .It appears that that the superimposition of fluvial cycle on the earlier glaciated valley in the upper part and mass wasting processes associated with the weaker zones /planes have also played the vital role in forming the epigenetic gorges, It is morphotectonic manifestation and is related with tectonic activity in the area of watershed of Alaknanda.The three level of epigenetic gorges in Alaknanda valley are identified at an elevation of 5m, 8m and 12m from present day course of Alaaknanda indicate cyclic rejuvenation of stream in recent past.

In Alaknanda around Hanuman Chatti and Hillong tilt in the hanging moraine, association of nick points in river bed of Vishu Ganga near Vinay Chatti , association of rock slide with steep rock cliff north of Joshimuth , occurrence of active land slide around Depoban in Dhauli ganga and Patal Ganga and dissected cones of cirque moraines both in Vishnu Ganga and Dhauli Ganga are noticed these are positive evidences of neotectonisam in Himalaya Khan (1981). Further indicate that tectonically area is active and slow movements are taking place along the thrust /faults /and lineaments traversing the area which is matter of concerned and needs attention of scientist.

The gradient of Alaknanda river in Karangpryag and Deoprayag is about 1:265, while Srinagar and Deoprayag is 1:165, forming an overall upward convex profile. The gradient of terraces between these two sections is 1 in 310 and 1 in 245 respectively. According to Sinha & Khan ((1975) the upward convexity might possibly be due to recent movement along the Srinagar Nalupani fault/thrust crossing the Alaknanda.

In Bhilangna valley the average gradient of the terraces and channel is 1:120 towards downstream , however , the terraces have little lesser gradient than the river channel, which might indicates that presently river is slowly under cutting its bed. Again there is slight reduction in the gradient of terraces between Dowal and Asena , the gradient is slightly more towards upstream and downstream. There is possibility that this is the result of Neotectonic movement along the Srinagar Naluoani fault/thrust which runs oblique to the river through Dewal. The Bhilangna terraces at Dewal have been dissected and displaced along the fault Sinha & Khan ((1975). The fluvial terraces of Pindar around Simli show upward movement and tilt towards north east. The tilt in some adjacent terrace is of order of 5 degree toward south east. The up warping and tilt has caused perceptible displacement in the pebble bed of terraces and caused reverse plunge of pebble axis , which indicates the area is active and recent movement are taking place along the lineament/ faults in the area. Khan (1975)

The longitudinal profile of Nandakini is quite simple as compared to Alaknanda. The slope of profile is slightly concave, smooth and has gradual slope. The profiles of fluvial terraces in general follow the profile of present day channel. It appears that Nandakani has adjusted its course along some weaker planes during up rise of head ward ends during the Holocene times (Khan 1981).The gradient of river bed of Nandakani between Nanala and Nandprayag is 1:0.55 Nanala and Ghat 1:2.77 respectively. In the area around Chamtali there is a sudden fall in the bed slope, indicating some up warping activity in Nandakini in recent past. The profile of fluvio-glacial terraces is suspended in nature; it pinches out upstream against the glacial terraces and downstream against the terraces of fluvial domain and perhaps represents the transitional phase of sedimentation in the valley. The profile of glacial terraces is restricted upstream of Nanala,where glacial terraces/glacial moraine are mostly dissected and discontinuous in nature and thereby indicating extensive erosion by renewed depositional activities subsequent to the recede of glacier in post-Pleistocene times.

The longitudinal profile of Mandakini terraces in general is concave with mild convexity in the area around Rampur and Tilwara. The profile of river bed is steep to gentle, between Kund Chatti and Augustmuni, it has gradient 1:10, Agustmuni and Rampur, 1:5, whereas between Rampur and Rudraprayag, the gradient is considerably reduced and profile has become nearly flat. The profile of both river terraces and river bed is slightly convex upward between

Agustmuni and Tilwara. It possibly indicates some differential up warping in the area (Khan in press), caused by some recent movement along lineaments and faults.

The fluvial terraces generally have uniform thickness and gradual gradient in Rudraprayag and Bhatwari section whereas upstream of Bhatwari it is considerably reduced. The average gradient of these terraces between Rudraprayag and Bhatwari is 1:4.4, 1:4.4 and 1:5.56, respectively. The profile of fluvio-glacial terraces is restricted in the middle part of the valley; it is truncated upstream against the profile of glacial and downstream against the fluvial terraces, which suggests the transition phase of sedimentation between the domains of these two terraces in the valley during the quaternary times. The average gradient of these terraces in the valley is 1:52. The profile of glacial terraces restricted upstream of Agustmuni, it has gradients of 1:9.33, between Kund Chatti and Bhatwari, in Sonparyag section it is of order of 1:92.In Kedarnath and Kund Chatti it become steep and represent rock cut terraces capped by glacial moraines.

The general shape of profile of Pindar River is concave and gentle with isolated convexity and steepness at places. The concavity and gentle shape of profile indicates the graded nature and balanced cutting of the river bed, while the convexity indicates comparatively good competence of rock constituting the river bed which is still under active cutting. The convexity in the channel profile in lower Pindar is perhaps due to deposition of coarser material in the river bed by tributaries joining Pindar in the lower segment of valley. The association of innumerable channel braids indicates under loading of channel due to loss of bed slope and low energy condition. The convexity in a river profile appear due to recent movements along the lineaments traversing the area which has also caused shifting of terrace block and tilt in older terraces in valley Khan (1975).

Epigenetic Gorges and Fossil Valley in Alaknanda:

The Alaknanda River descends across the Himalaya 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 Ganser 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 rocks of variable dimensions. These epigenetic gorges were formed 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.It is also supplemented by sudden change in the Kinetics of the stream system due to tectonic and neotectonic activity along thrust/faults and lineament traversing the area in Quaternary times. In Alaknanda between Karanprayag and Srinagar at about ten places the epigenetic gorges have noticed.

These occur near Karanprayag, Bamoth, Gharkot, Dharkot, Ratura, Trini, Uttiyasu, Kaliasour, Koteshwar and Srinagar are described below: (Plate No.13).

Geomorphic Evolution Of Fluvial Terraces In Alaknanda And Its Tributaries

The Quaternary period was heralded by widespread glacial activity in Himalaya. It is considered that there were at least four periods of glaciations with three intervening inter glacial period during the Pleistocene time. With the advent of Holocene the glaciers in Himalaya began to recede due to major climatic changes and as a sequel large volume of water impounded in glacier was released to the major antecedent rivers descending the Himalaya.

In the Holocene time the area experienced the major tectonic/eustatic and climatic changes which renewed the erosional and depositional activity superimposed their creation on the pre-existing topography and reshaped the morphogenetic expressions of the basin. As witnessed by the occurrences of as many as six prominent regional terraces in Alaknanda, the trunk stream of Ganga System, there have been at least six pulses of uplift, aided by the climatic changes Khan (1981) (1987). The Alaknanda was the first major streams to emerge on the surface, following subsequently by Bhagirathi, Bhilangna, Nandakini, Mandakini/Pinder/Dhauli-Ganga ,Madhmeshwar Ganga and Berhi-Ganga the tributaries, each characterized by five, four, three two and one terrace respectively.

Based on the parameters like terrace correlation both inter and intra valley wise, their regional disposition and occurrence, the following sequential order of valley development in Ganga basin in parts of Garhwal Himalaya is established is as follows Khan et.al. 1981), Khan (1981,1987).

Sequence of valley development

Stage – VI	:	Berhi – Ganga	One level of terrace
Stage – V	:	Madhmeshwar	Two level of terrace
Stage – IV	:	Bal Ganga, Mandakini, Pindar Dhauli Ganga	Three level of terrace
Stage – III	:	Bhilangna=, Nandakini	Four level of terrace
Stage – II	:	Bhagirathi	Five level of terrace
Stage – I:		Alaknanda	Six level of terrace

Based on the sequence of valley development the following sequential order of terrace development is established .

Sequential order of terrace development :

Alaknanda	Bhagi-rathi	Bhila-Ngna	Nanda kini	Manda-kini	Pindar	DhauliGanga	Bal Ganga	Madh Mesh war Gang	Berhi Ganga
1	-	-	-	-	-	-	-	-	-
2	1	-	-	-	-	-	-	-	-
3	2	1	1	-	-	-	-	-	-
4	3	2	2	1	1	1	1	-	-
5	4	3	3	2	2	2	2	1	-
6	5	4	4	3	3	3	3	2	1
Stages of valley development	II	III =	III	IV =	IV =	IV =	IV	V	VI

The occurrences of as many as six terraces in Alaknanda indicate the six pulses of uplift in the watershed region of river in Quaternary times. During the intermittent period of successive uplift peni-planation of flood plain occurred, whereas during the phase of upraise streams were forced to abandon their flood plains and regionally adjusted their base level in relation to the newly formed eaustatic levels, the readjustment of catchment after the release of large quantity of water.

On the basis of terrace correlation, valley development sequential order of terrace development their relation to the uplift/eaustatic/ climatic changes and different phases of rejuvenation of channel the following order of terrace development is suggested.

Spatial Order Of Terrace Development

--------	Alaknanda	Bhagirathi	Bhalangna	Nandakini	Mandakini	Pindar	Dhauli Ganga	Gal Ganga	Madhmeshwar Ganga	Berhi Ganga
I	AT_6	-	-	-	-	-	-	-	-	-
II	AT_5	BT_5	-	-	-	-	-	-	-	-
II	AT_4	BT_4	BHT_4	NT_4	-	-	-	-	-	-
IV	AT_3	BT_3	BHT_3	NT_3	MT_3	PT_3	DGT_3	BGT_3	-	-
V	AT_2	BT_2	BHT_2	NT_2	MT_2	PT_2	DGT_2	BGT_2	MDT_2	-
VI	AT_1	BT_1	BHT_1	NT_1	MT_1	PT_1	DGT_1	BGT_1	MDT_1	BBT_1

The occurrences of six terraces in Alaknanda correspond to the six phases of uplift/eustatic/climatic changes in the head ward of Ganga system in Holocene time.

In the first phase of uplift/eustatic/climatic changes, Alaknanda formed its first and oldest terrace, i.e. AT_6.

In the second phase, while Alaknanda had already formed one terrace, the Bhagirathi joined the scene of terrace building activity and subsequently formed the terrace, 1.e. (BT_5), simultaneously with AT_5 of Alaknanda.

In the third phase, the other tributaries viz. Bhilangna, Mandakini, developed their first terrace viz BHT_4, NT_4, simultaneous with the AT_4 of Alaknanda, and BT_4, of Bhagirathi.

In the fourth phase the Mandakini, Pindar, Dhauli Ganga and Bal Ganga developed their first terrace viz. MT_3, PT_3, DHT_3, and BGT_3, contemporaneous to AT_3 of Alaknanda, BT_3, of Bhagirathi, BHT_3, of Bhilangna, NT_3, of Nandakini.

In the fifth phase the Madhmeshwar Ganga the youngest tributary of Ganga system entered in terrace building activity and formed its first terrace MDT_4), simultaneously with AT_2, of Alaknanda. BT_2 of Bhagirathi. BHT_2, of Bhelangna, NT_2, of Nandakini, MT_2, of Mandakini, PT_2, of Pindâr, DHT_2, of Dhauli Ganga and BGT of Bal Ganga.

In the sixth phase the Madhmeshwar Ganga formed its second terrace ie. MDT_1 simultaneously with AT_1, of Alaknanda, BT_1, of Bhagirathi, BHT_1 of Bhelangna, NT_1, of Mandakini, MT_2, of Mandakini, PT_1 of Pinder, DHT_1, of Dhauli Ganga and BGT_1, of Bal Ganga, MDT_1, of Madheshwar Ganga and BRT_1, of Berhi Ganga.

It is evident that in the post-Pleistocene time the Ganga Basin area has undergone the process of aggradation, degradation six times. Each aggradations phase was intervened by the phase of degradation during the course of uplift. On the above basis, the spatio-temporal order delineating the phase of aggradations and degradation phases of Quaternary sedimentation is suggested as below: (Table No.21)

Conclusionn:-

The Geological and Geomorphological study in Upper Ganga basin has been attempted in parts of Uttarkashi,Chamoli, Pauri and Tehri districts an area of 10000 Sq.kms in parts of QA sheet 53J and 53 N on 1000000/ 1:50000 scale of Garhwal Himalaya U.P; presently known as Uttrakhand State of Union of India.

The area of Upper Ganga basin consisting of drainage net of Alaknanda,Bhagirathi,Bhilangna, Nandakini, Mandakini, Pindar, Dhauli- Ganga Bal- Ganga , Madhmeshwar Ganga and Berhi Ganga. The Alaknanda embraces and and chracterised by six fluvial terraces besides terraces followed by Bhagirathi with five terraces , Bhilangna Nandakini four terraces Mandakini /Pindar/Dhauli-Ganga /Balganga three terraces , Madhmshwar Ganga two terraces and Bherhi Ganga one terrace besides glacial and fluvio-glacal terraces, amidst, these Alaknanda is trunk stream and others are tributaries. The area genetically comprised of terraces of three domains, viz. glacial, fluvio-glacial 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 m.s.l. the fluvio-glacial terraces at an average elevation of 975m above m.s.l. and Fluvial terraces at an average elevation between 650 to 900 m above m.s.l.

The Alaknanda has formed six prominent regional terraces in the valley. These have been designated as AT0, to AT6. The AT0, being the low level surface above the present day course of the river being a part of active flood plain. The AT1, being the youngest and AT6, being the oldest terrace in the area. Each of these terraces is separated by the scarp both of linear and curvilinear in nature facing towards river. These terraces are both erosional and depositional in nature and display divergence and convergence in their relative disposition. The erosional terraces are generally seen as isolated pockets and lenses resting over the country rocks along the higher part of the valley flanks, representing the former levels of valley floors. In general these terraces are very ill preserved and have very few matched equivalent in the valley. The occurrences of these terraces and associated features in the higher parts of valley indicate the rigorous and abrupt incision of valley floors due to relatively rapid and sudden uplift of watershed region of Alaknanda during the early Holocene times.

The complete sequence of terraces in the valley is seen at very few places viz. around Srinagar, Koteshwar, Rudraprayag, Nagrasu and Gauchar which give almost the complete account of tectonic and climatic changes in the area; whereas at other places one, two or three terraces are preserved, and many other have been eroded away.. It indicates incisive as well as rapid migrating nature of the stream. These terraces are both paired and unpaired and display convergence and divergence in their relative disposition. The divergence and pairing in general is seen in the older terraces viz. AT6, AT5, and AT4, whereas the younger terraces viz. AT1, AT2 and AT3, display convergent in their disposition and mostly remained unpaired.

The divergence and pairing in the older terraces indicate the abrupt and sudden incision of the valley floor due to relatively sudden upraise of head ward ends of the Alaknanda and consequent climatic changes, in the early Holocene times. The convergence and un-pairing in younger terraces, on the contrary, indicate decrease in rate of uplift and long interval climatic change towards the later phases of sedimentation in the valley. The pairing, un-pairing and relative disposition of terraces as whole in Alaknanda suggests the constant and steady decrease in rate of uplift in Himalaya from early to late Holocene time.

Alaknanda is Antecedent River which traverses across the strike of Himalayan ranges and negotiate both across and along thrust/fault and linaments.The channel morphology of Alaknanda is diverse and associated various diagnostic morphotectonic features and elements, amidst these the epigenetic gorges which are associated at different level i.e. at 5m, 10m, 12m, and 15m within the present valley suggest the channel system has been under tremendous stress and under tectonic influence. It was governed and controlled by consequential and residual energy system and frequential newly generated energy system by neotctonic movements along thrust/fault/lineaments traversing the area. The disposition of epigenetic gorges and their association with Alaknanda suggests at least three major tectonic events in Holocene time. The morphogenetic illustration of channel morphology of Alaknanda indicates that area is active, sensitive and prone to Earthquake.

The-Himalayan thrust like Central thrust Srinagar thrust, Alaknanda fault, Tons thrust, show flattening dip suggesting that they lie at comparatively at shallow depth at short distance, down dip from their out crops, recent movements along the trace of these faults /thrust are unpredictable the slow movements along these thrust /faults have considerably affected Quaternary terraces of glacial, fluvio-glacial and fluvial domain of Alaknanda and its tributaries. Beside drainage, river bed profile, landscape architect and over all morphogenetic expression of the area, bears the imprints of neotectonisam which revealed that the area is under stress, active sensitive, and posed to earthquake.

The area of study, morphtectonically and morphogenetic North of Wazri in Jamuna valley,North of Uttarkashi in Bhagirathi valley, around Tugnath and Chamoli and South of Joshimuth in Alaknanda valley revealed that there is sharp curvilinear break in morphogenetic expression of the area, which appears to be due to horizontal movement of some sub - tectonic plates towards south , which is causative factor in dislocation in tectonic ecology of the area, it is matter of serious concerned and needs further attention

Table 11:- Salient features of fluvial terraces in type area of Alaknanda Valley.

(i) Locality : Srinagar (30^0 12' – 78^0 47')

Terrace and its Designation

	River bed	AT_1	AT_2	AT_3	AT_4	AT_5	AT_6
Age		**Holocene**					
Elevation above MSL (m)	600	600	615	635	650	670	690
Geomorphic break (m) -	15	20	20	15	20	20	
Elevation above RB (m)	-	20	35	55	70	90	110
Slope	----- Towards west -----		----Towards SW ----		Towards west -----		
Nature of surface	----- Depositional ---------			---- Erosional ------			
Cycle sedimentation -	---------- Polycycle --------------------------				Not exposed -------------		
Orientation of L-Axes -	NW-SE	E-W	NNE-SSW		NE-SW	E-W	E-W
Plunge of L-Axes -	----- Towards East --------------------------				Towards NE -------		Towards West ----------
Relative disposition -	Divergent	Divergent	Convergent		Divergent ----------------------------------		
Paired / Unpaired -	Unpaired	Paired	Unpaired	Paired	Paired	Isolated Patches	
Nature of scarp -	------------------ Curvilinear --------------------				------------- Linear -------------- Curvilinear		

Sedimentary features - ------- Not exposed -------a) Graded bedding Cross -
b) Cross bedding bedding
c) Lamination and cross limitation

Terrace Shape - Cuspate Rectangular -- Semi-Circular

Isolated cap

Land use pattern - ------------------------------- Inhabitation and cultivation ---

Composition/Litho constituents Arranged in probable order of abundance

River bed :- Quartzite, granite, gneiss, schist, basic, phyllite, slate, shale and sand

AT_1 :- Quartzite, gneiss, granite, schist, basic, limestone, phyllite, slate and sand.

AT_2 :- Quartzite, gneiss, granite, schist, phyllite, slate, sand and silt.

AT_3 :- Quartzite, gneiss, granite, fossiliferous, limestone, basic, phyllite, slate, shale, sand and silt.

AT_4 :- Quartzite, gneiss, granite, basic, schist, phyllite, slate, shale, sand and silt.

AT_5 :- Quartzite, gneiss, granite, basic, schist, phyllite, slate, shale, sand, silt and clay

AT_6 :- Quartzite, limestone, gneiss, granite, schist, phyllite, slate, shale, sand, silt and clay.

**** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

(ii) Locality : Pharasu (30^0 14-30" – 78^0 52'.00")

Terrace and its Designation

	River bed	AT_1	AT_2	AT_3	AT_4	AT_5	AT_6
Age		Holocene					
Elevation above MSL (m)	605	615	635	660	675	700	725
Geomorphic break (m) -	15	20	25	15	25	25	
Elevation above RB (m)	-	15	35	70	85	110	135
Slope	Towards SW	----Towards West --------------------- Towards South West --------------------------------					
Nature of surface	Depositional	Erosional	Depositional		Depositional	------ Erosional ---------	
Cycle sedimentation -	---------- Uncycle -----------			------Polycycle ----------		---Not fully exposed --	
Orientation of L -Axes -	E-W	NNE-SSW	NE-SW	NW-SW	NW-SW	NW-SW	
Plunge of L-Axes -	----- Towards East -------------------------- Towards NW ------- Towards North ----------						
Relative disposition -	-------- Convergent -------------			----------- Divergent ---			
Paired / Unpaired -	--------------- Unpaired ------------			------	------------------ Paired		------------------
Nature of scarp -	------------------- Curvilinear -------------------			------------- Linear -------------			
Sedimentary features -	Graded Bedding, Cross Bedding, lamination,cross bedding, cross ,lamination, cut & fill features						

Terrace Shape - Cuspate ------- Rectangular ---------------------- Semi-Circular ------ circular
Land use pattern - ------------------------------ Inhabitation and cultivation -------------------------- --------------
Composition/Litho constituents Arranged in probable order of abundance
River bed :- Quartzite, gneiss, schist, basic, slate, shale, limestone and sand
AT_1 :- Quartzite, gneiss, granite, schist, , phyllite, slate, shale and &sand.
AT_2 :- Quartzite, limestone (fossiliferous), gneiss, granite, phyllite, slate, shale and basic.
AT_3 :- Quartzite, gneiss, sandysilt, granite, schist, limestone, phyllite, slate, shale, sand and silt.

AT_4 :- Quartzite, gneiss, Fossiliferous, limestone, phyllite, slate, basic, shale, sand, silt and clay
AT_5 :- Gneiss, granite, quartzite, schist, slate, shale, sand, silt and clay
AT_6 :- Quartzite, granite, schist, limestone, gneiss, basic, slate, , sand, silt and clay.

**** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblateprolate and bladed in shape.**

(iii) Locality : Rudraprayag and Ultiyasu Area (32^0 30' 00 – 79^0 57'30")

Terrace and its Designation

	River bed	AT_1	AT_2	AT_3	AT_4	AT_5	AT_6
Age		**Holocene**					
Elevation above MSL (m)	**625**	**635**	**650**	**670**	**685**	**715**	**740**
Geomorphic break (m) -	**10**	**15**	**20**	**15**	**30**	**25**	
Elevation above RB (m)	**-**	**10**	**25**	**45**	**60**	**90**	**115**

Slope ------------------ ------------------- -------------------- Towards South West ---
Nature of surface - ------------------------------------- Depositional -------------------------------------- - Erosional
Cycle sedimentation - Section not Fully exposed | Section not fully exposed | Unicycle ------------- Polycycle ----------
Orientation of L-Axes ------------------------- North East ------------------------------- South West -------------------- -------------------
Plunge of L-Axes - 5^0 towards north east 10^0NE 9_0NE 10^0N
Relative disposition - --------------------------- Divergent -- Occur as islated caps
Paired / Unpaired - --- Unpaired ---------------------------- --------------
Nature of scarp - -------------------------------- Linear -- Curvilinear
Sedimentary features - Graded Bedding
cross bedding
cut & fill features
lamination &
Cross lamination --

Terrace Shape - --------------------- Rectangular -- --------------Circular

Land use pattern - ------------------------------ Inhabitation and cultivation -------------------------- --------------

Composition/Litho constituents River bed :- Quartzite, gneiss, granite, schist, basic, phyllite, shale,
Arranged in probable order of limestone and micaceous sand.abundance AT_1 :- Quartzite, slate, phyllite, basic, gneiss, granite, fossiliferous,
Limestone and sand.

AT_2 :- Quartzite, slate, basic, phyllite, gneiss, granite, schist, fossiferous limestone, sand and silt.

AT_3 :- Quartzite, gneiss, granite, schist, basic, slate, , fossiliferous, limestone silt, sand and clay.

AT_4 :- Quartzite, gneiss, granite, schist, basic, slate, phyllite, Fossiliferous, limestone, silt, sand and clay.

AT_5 :- Quartzite, gneiss, granite, schist, limestone, slate, red, silt, phyllite, sand and clay

AT_6 :- Quartzite, granite, schist, gneiss, limestone, phyllite, slate, sand, silt and clay.

The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.

(iv) Locality : Nagrasu (32^0 17' 25" – 79^0 10'00")

Terrace and its Designation

		River bed	AT_1	AT_2	AT_3	AT_4	AT_5	AT_6
Age ______________________			Holocene	______________	______________	______________	______________	
Elevation above MSL (m)		650	670	695	710	745	765	790
Geomorphic break (m)	-	20	25	15	35	20	25	
Elevation above RB (m)		-	20	45	60	95	115	140
Slope Towards --------------------		Towards west	------------------		SW	SW	----------------	
Nature of surface	- Erosional	Deposi	Erosi	--------------		Depositional	-----------------	
Cycle sedimentation	-	-	Unicycle	-------------	Polycycle	--------------------	--------------------	
Orientation of L -Axes	-	NW-SE	NW-SE	NW-SE	NNE-SSW	E-W	E-W	
Plunge of L-Axes	- East	5^0 towards NE	5^0 towards North	5^0 towards NW	5^0 to 10^0 towards North	5^0 to 10^0	10^0 towards towards	East
Relative disposition	- Isolated Caps	--------------------	Divergent -----	------	convergent	- -----------	divergent	
Paired / Unpaired	- Unpaired	--------- Unpaired	----------		Paired	---------	Unpaired	----------
Nature of scarp	-------	-------- Linear		----------	---------- Curvilinear	--------------------------- ----------------		
Sedimentary features	-	----------------------------------- Graded Bedding ------------------------------------ --------------						
		Cross Bedding Lamination	Lamination & cut and fill features		- lamination	Graded lamination cross cross bedding and cut and fill features		
Terrace Shape	-	cuspate	Rectangular		----	Semi Circular	--------- Isolated semi	

Circular to circular lences

Land use pattern - ------------------------------ Inhabitation and cultivation -------------------------- --------------

Composition/Litho constituents Arranged in probable order of abundance

River bed :- Quartzite, gneiss, granite, schist, basic, slate, phyllite, shale, fossiliferous, limestone and sand.

AT_1 :- Quartzite, gneiss, granite, schist, slate, phyllite, basic, shale, limestone, silt and sand.

AT_2 :- Quartzite, gneiss, granite, phyllite, limestone, fossiferous slate, shale, sand and silt.

AT_3 :- Quartzite, gneiss, granite, Fossiliferous, limestone,basic,phyllite Slate, shale, sand and silt.

AT_4 :- Quartzite, gneiss, granite, limestone, shale, basic, slate, Coarse to yellow sand, yellow purples silt and clay.

AT_5 :- Quartzite, gneiss, granite, schist, basic, shale, slate, Purple sand, red silt and clay.

AT_6 :- Granite, schist, gneiss, Fossiliferous, limestone, phyllite, slate, , And slate red fine sand, silt and clay.

**** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

(v) Locality : Gauchar-Bamoth (30^0 17' 30" – 79^0 10'00") (Photo No.21)

Terrace and its Designation

	River bed	AT_1	AT_2	AT_3	AT_4	AT_5	AT_6
Age		**Holocene**					
Elevation above MSL (m)	**650**	**670**	**690**	**715**	**745**	**785**	**800**
Geomorphic break (m) -	**20**	**20**	**25**	**30**	**40**	**15**	
Elevation above RB (m)	**-**	**20**	**40**	**65**	**95**	**135**	**150**
Slope	**-**	**Towards west**		**-------**	**NW**	**West**	**NW**

West

Nature of surface - ---------- Depositional -------------- Section not Polycycle Section full exposed full exposed

Cycle sedimentation - Unicycle Polycycle -------------

Orientation of L -Axes - -------------NW – SE -------------------------- E-W NW-SE E-W

Plunge of L-Axes - ------ 5^0 to 10 towards North East --- -------------

Relative disposition - Convergent ----------- Divergent ----------- Convergent ----------- Divergent ------------

Paired / Unpaired - --- Paired ------------------------------------ -------------

Nature of scarp - --------------------- Linear ------------------- ---------- Curvilinear ------------- ----------------

Sedimentary features - ------------------ Cross bedding, graded bedding, lamination, cross lamination and cut and fill features ------------------

Terrace Shape - ---------------- cuspate ----------- Semi Circular -------------------------------- -------------------

Land use pattern - ------------------------------ Inhabitation and cultivation -------------------------- --------------

Composition/Litho constituents Arranged in probable order of River bed :- Quartzite, slate, phyllite, basic, gneiss, granite, limestone and micaceous sand.

AT_1 :- **Quartzite, gneiss, granite, schist, slate, basic,limestone shale, and micaceous sand.**

AT_2 :- **Quartzite, gneiss, granite, fossiferous, limestone, phyllite, slate Shale, sand, silt and clay.**

AT_3 :- **Quartzite, phyllite, gneiss, granite, slate, basic, schist, shale, Fossiliferous, limestone, sand, silt and clay.**

AT_4 :- **Quartzite, gneiss, granite, schist, fossilifeous, limestone, phyllite, slate, sand silt and clay**

AT_5 :- **Quartzite, gneiss, granite, schist, slate, fossiliferous, limestone, Phyllite, silt, clay and sand.**

AT_6 :- **Granite, schist, gneiss, granite, fossiliferous, limestone, phyllite, slate, clay, silt and sand.**

**** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

Table -12:- Salient Features Of Fluvial Terraces In Type Area Of Bhagirathi Valley.

(i) Locality : Tehri 30^0 28' 22" : 78^0 22' 48"

Terrace and its Designation

	River bed	BT_1	BT_2	BT_3	BT_4	BT_5
Age	**Holocene**					
Elevation above MSL (m)	**427**	**432**	**440**	**447**	**456**	**462**
Geomorphic break (m)	**-**	**5**	**8**	**7**	**9**	**5**
Elevation above RB (m)	**-**	**5**	**13**	**20**	**29**	**34**
Slope	**-**	**Towards south**	**Towards south**	**Towards south**	**Towards south**	**Towards south**
Nature of surface	**-**	**Depositional**	**Depositional**	**Depositional**	**Erosional**	**Erosional**
Cycle sedimentation	**-**	**Polycycle**	**Polycycle**	**Polycycle**	**Polycycle**	**Polycycle**
Orientation of L -Axes	**-**	**NW-SE**	**NW-SE**	**NW-SE**	**NW-SE**	**N-S**
Plunge of L-Axes	**-**	**5^0 to 15^0 North**	**5^0 to 15^0 North**	**5^0 to 15^0 North**	**5^0 to 15^0 North**	**5^0 to 15^0 North**
Relative disposition	**-**	**Convergent**	**Convergent**	**Convergent**	**Convergent**	**Convergent**
Paired / Unpaired	**-**	**Unpaired**	**Unpaired**	**Unpaired**	**Paired**	**Paired**
Nature of scarp	**-**	**Curvilinear**	**Curvilinear**	**Curvilinear**	**Linear**	**Linear**
Sedimentary features	**-**	**Graded bedding, cross lamination cut and fill features ----------------------**				
Terrace Shape	**-**	**--------------- cuspate , elongated and lensoid ------------------------------------ ------------**				
Land use pattern	**-**	**------------------------------- Inhabitation and cultivation ------------------------- --------------**				

Composition/Litho constituents Arranged in probable order of abundance

River bed :- **Quartzite, gneiss, schist, slate, limestone, coarse to file sand.**

BT_1 :- **Quartzite, gneiss, granite, schist, phyllite, basic and limestone with very coarse to fine sand and silt.**

BT_2 :- **Quartzite, gneiss, granite, limestone, phyllite, schist and basic with Very coarse to fine and silt.**

BT_3 :- **Quartzite, gneiss, granite, basic, schist, limestone with Coarse to fine sand.**

BT_4 :- **Quartzite, gneiss, granite, schist, basic, slate, phyllite, Coarse to tine sand, silt and clay.**

BT_5 :- **Gneiss, granite, schist, phyllite, slate, coarse to fine sand.**

** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded

.

(ii) Locality : – Chinyalli Saur (Photo No.63)
(30^0 31' 52" : 78^0 22' 20")

Terrace and its Designation

	River bed	BT_1	BT_2	BT_3	BT_4	BT_5	
Age		Holocene					
Elevation above MSL (m)		429	436	446	454	464	472
Geomorphic break (m)		-	7	10	8	10	7
Elevation above RB (m)		-	7	17	25	35	42
Slope		-	-----------	Towards south		-----------	----------
-	-----------						
Nature of surface	-	Depositional	Depositional	Depositional	Depositional	Erosional	
Cycle sedimentation	-	Polycycle	Polycycle	Polycycle	Polycycle	Polycycle	
Orientation of L -Axes		-	5^0 to 10^0 ----------- N – S ---				

Plunge of L-Axes	-		5^0 to 10^0 ----------- towards north ---------------------------------				

Relative disposition	-	-----------	Convergent ------------------------------------- Divergent				
Paired / Unpaired	-	Unpaired	Unpaired	Unpaired	Unpaired	Paired	
Nature of scarp	-	Curvilinear	Curvilinear	Curvilinear	Curvilinear	Linear	
Sedimentary features exposed	-	----- Graded bedding & cut & fill features -------------- Section not well					
Terrace Shape	- Elongate	------------------------Crecent ---					
Land use pattern	-	------------------------------- Inhabitation and cultivation -------------------------					

Composition/Litho constituents Arranged in probable order of abundance

River bed :- Quartzite, gneiss, granite, schist, phyllite, slate, limestone, micaceous meta-volcanic, coarse to fine sand.

BT_1 :- Quartzite, gneiss, granite, schist, phyllite, slate, limestone, micaceous, meta-volcanic, coarse to fine sand.

BT_2 :- Quartzite, gneiss, granite, limestone, schist, meta-volcanic, slate, Coarse to fine sand.

BT_3 :- Quartzite, gneiss, granite, schist, basic, phyllite, slate and occasional, Meta-basic and coarse to fine sand silt and clay.

BT_4 :- Quartzite, gneiss, granite, schist, phyllite, and slate with very coarse To very fine sand, silt and clay

BT_5 :- Quartzite , gneiss, granite, schist, phyllite, slate with very coarse to very fine silt and clay.

** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.

(iii) Locality : Dunda
(30^0 41' 51" : 78^0 21' 05")

Terrace and its Designation

	River bed	BT_1	BT_2	BT_3	BT_4	BT_5	
Age		**Holocene**					
Elevation above MSL (m)		**448**	**451**	**456**	**463**	**468**	**473**
Geomorphic break (m)		**-**	**3**	**5**	**7**	**5**	**10**
Elevation above RB (m)		**-**	**3**	**8**	**15**	**20**	**30**
Slope	-	**-**	**-----------**	**Towards SW**		**-----------**	**----------**

Nature of surface - Depositional Depositional Depositional Depositional Erosional
Cycle sedimentation - ------------- Unicycle ------------------------------------ Polycycle Polycycle
Orientation of L -Axes - ------------- 10^0 to 25^0 NW-SW 5 – 15 N-W --------- 10^0. 20^0 NE-SW -----
Plunge of L-Axes - 5^0 to 10^0 ---------- towards north --- -----
Relative disposition - ------------------ Convergent ------------------------- ----------- Divergent ---------
Paired / Unpaired - Unpaired Unpaired Unpaired Paired Paired
Nature of scarp - Curvilinear Curvilinear Curvilinear Linear Linear
Sedimentary features - Graded bedding, cross bedding Lamination, cross lamination; Section not fully exposed
Terrace Shape - ------------- Semi circular -------------------- Elongate ---------------- Rectangular
Land use pattern - ------------------------------ Inhabitation and cultivation ------------------------ -------------

Composition/Litho constituents Arranged in probable order of abundance

River bed :- Quartzite, gneiss, granite, schist, phyllite, slate, limestone meta-volcanic and coarse to fine micaceous sand.
BT_1 :- Quartzite, gneiss, granite, schist, phyllite, slate, limestone meta-volcanic, coarse to fine sand.
BT_2 :- Quartzite, gneiss, granite, phyllite, slate, limestone, basic and Coarse to fine sand.
BT_3 :- Quartzite, gneiss, granite, schist, phyllite, slate, limestone, Coarse to fine sand, silt and clay.
BT_4 :- Quartzite, gneiss, granite, schist, phyllite, slate coarse to fine Sand, silt and clay.
BT_5 :- Quartzite , gneiss, granite, schist, slate and very coarse to very fine sand and clay.

**** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

(iv) Locality : Uttarkashi
(30^0 43’ 00” : 78^0 26’ 00”)

Terrace and its Designation

	River bed	BT_1	BT_2	BT_3	BT_4	BT_5	
Age		**Holocene**					
Elevation above MSL (m)		**460**	**464**	**469**	**474**	**479**	**491**
Geomorphic break (m)		**-**	**4**	**5**	**5**	**5**	**12**
Elevation above RB (m)		**-**	**4**	**9**	**14**	**19**	**31**

Slope	-	----------- Towards West ----------- ---------- - -----------			
Nature of surface -	Depositional	Depositional	Depositional	Erosional	Erosional
Cycle sedimentation -	------------- Not exposed --------------------------- Polycycle -------------------- ------				
Orientation of L -Axes	-	------------- Towards NW --- -------------------------			
Plunge of L-Axes -	---------- 5^0 to 12^0 ----------- towards west -------------- 15^0 -20^0 east ---------- -----				
Relative disposition -	------------------- Convergent ------------------------- ----------- Divergent ---------				
Paired / Unpaired -	Unpaired	Unpaired	Unpaired	Paired	Paired
Nature of scarp -	Curvilinear	Curvilinear	Curvilinear	Linear	Linear
Sedimentary features -	---------------- Graded bedding ------------------ Cross lamination Lamination and cut and fill feature				Graded bedding & cut & fill features
Terrace Shape -	------------- Crecent -------------------------------- ---------- Lensoid ------------ ------------				
Land use pattern -	------------------------------- Inhabitation and cultivation ------------------------ -------------				

Composition/Litho constituents Arranged in probable order of abundance	River bed :-	Quartzite, gneiss, granite, schist, limestone, meta-volcanic and coarse to fine sand.
	BT_1 :-	Quartzite, gneiss, granite, schist, phyllite, slate meta-volcanic, coarse to fine sand.
	BT_2 :-	Quartzite, gneiss, granite, phyllite, slate and coarse to fine sand.
	BT_3 :-	Gneiss, granite, schist, phyllite, slate, limestone and Coarse to fine sand.
	BT_4 :-	Gneiss, granite, schist, phyllite, slate, limestone coarse to fine Sand, silt and clay.
	BT_5 :-	Gneiss, granite, schist, phyllite, slate and very coarse very fine sand, silt and clay.

**** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

Table 13:- Salient Features Of Fluvial Terraces In Type Area Of Bhillangna Valley
(i) Locality : Tehri – Simlasau (Photo No.64-65)
(30^0 43' 15" : 78^0 26' 15")

Terrace and its Designation

	River bed	BHT_1	BHT_2	BHT_3	BHT_4
Age	Holocene				
Elevation above MSL (m)	605	619	632	645	655
Geomorphic break (m)	-	14	13	12	10
Elevation above RB (m)	-	14	27	39	49
Slope	-	--------------------------------- Towards West and South West -------------------------------			
Nature of surface -	---------------------- Depositional --------------------- Erosional ------------------- ------------				
Cycle sedimentation -	-- Polycycle -------------------------------------- -------------				
Orientation of L -Axes	-	------------------------ Prodominently towards SW-W ------ ----------------------------------			

Plunge of L-Axes -	**5^0 to 15 ---------- Predominantly NE & E --- -------------**				
Relative disposition -	**------------------- Convergent --------------------- Rounded Isolate ------------------- ------**				
Paired / Unpaired -	**Unpaired**	**Unpaired**	**Paired**	**Paired**	
Nature of scarp -	**Curvilinear**	**Curvilinear**	**Curvilinear**	**Curvilinear**	
Sedimentary features -	**Graded bedding, cross bedding, Graded lamination, cross lamination Cut & fill feature -------------------------------**				
Terrace Shape -	**------------------------ Crecent shaped ------------------------ Rounded --------- -------------**				
Land use pattern -	**------------------------------- Inhabitation mainly ---------------------------------- ---------------**				

Composition/Litho constituents Arranged in probable order of abundance

River bed :- Quartzite, gneiss, granite, phyllite, slate, basic and limestone and sand.

BHT_1 :- Quartzite, gneiss, granite, phyllite, slate, basic and limestone and sand.

BHT_2 :- Quartzite, gneiss, granite, schist, basic, limestone and Coarse to fine sand.

BHT_3 :- Quartzite, gneiss, granite, limestone, schist coarse to fine Sand and silt.

BHT_4 :- Quartzite, gneiss, granite, limestone, schist with very coarse to very fine sand, silt and clay.

**** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

(ii) Locality : Dewal
(30^0 02' 27" : 79^0 33' 25")

Terrace and its Designation

	River bed	BHT_1	BHT_2	BHT_3	BHT_4
Age	**Holocene**				
Elevation above MSL (m)	**610**	**622**	**635**	**649**	**661**
Geomorphic break (m)	**-**	**12**	**13**	**12**	**14**
Elevation above RB (m)	**-**	**12**	**25**	**37**	**57**
Slope	**-**	**SW**	**SW**	**SW**	**SW**
Nature of surface -	**Depositional**	**Depositional**	**Erosional**	**Erosional**	
Cycle sedimentation -	**Not exposed**	**Not exposed**	**Not exposed**	**Not exposed**	
Orientation of L -Axes	**-**	**Predominantly**		**Predominantly**	
Predominantly		**Predominantly**			
	NW-SE	**NW-SE**	**NW-SE**	**NW-SE**	
Plunge of L-Axes -	**Variable**	**Variable**	**5^0-20^0NE**	**5^0-20^0NE**	
Relative disposition -	**Convergent**	**Convergent**	**Divergent**	**Divergent**	
Paired / Unpaired -	**Unpaired**	**Unpaired**	**Paired Shifted**	**Paired Shifted**	
Nature of scarp -	**Curvilinear**	**Curvilinear**	**Linear**	**Linear**	
Sedimentary features -	**--------------------------------------- Section not exposed ------------------------ -------------**				
Terrace Shape -	**Crecent**	**Crecent**	**Elongated Rectangular**	**Elongated Rectangular**	
Land use pattern -	**------------------------------ Inhabitation and Cultivation ----------------------- -------------------------**				

Composition/Litho constituents Arranged in probable order of abundance	River bed :-	Quartzite, gneiss, granite, phyllite, slate, basic, limestone, coarse to fine micaceous sand.
	BHT_1 :-	Quartzite, gneiss, granite, phyllite, slate, basic, limestone and coarse to fine micaceous sand.
	BHT_2 :-	Quartzite, gneiss, granite, phyllite, schist, slate, coarse to fine sand & silt.
	BHT_3 :-	Quartzite, gneiss, granite, phyllite, slate, schist and very Coarse to fine sand, silt and clay.
	BHT_4 :-	Gneiss, granite, phyllite, schist, slate and limestone and Very coarse to very fine sand and clay.

** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape & subrounded to well rounded.

(iii) Locality : Asena
(30^0 23’ 00” : 79^0 35’ 00”)

Terrace and its Designation

	River bed	BHT_1	BHT_2	BHT_3	BHT_4
Age	Holocene				
Elevation above MSL (m)	612	628	643	661	671
Geomorphic break (m)	-	16	15	17	10
Elevation above RB (m)	-	16	31	49	59
Slope	-	SW	SW	SW	SW
Nature of surface -	Depositional	Depositional	Erosional	Erosional	
Cycle sedimentation -	------------------------------ Polycycle		-----------------------		Not exposed
Orientation of L -Axes	-	------------------------------ Predominant South West -------- -------------------------------			
Plunge of L-Axes - North	5^0-10^0NE	--------------------------	5^0-25^0N	-------------------------	10^0-30^0N
Relative disposition -	Convergent	Convergent	Divergent	Divergent	
Paired / Unpaired -	Unpaired	Unpaired	Paired	Paired	
Nature of scarp - ---------	----------------------- Curvilinear		-------------------------- Not exposed -------------		
Sedimentary features - ------	------------------------	Cross bedding lamination, cross Lamination	Graded bedding		Not exposed -----
Terrace Shape -	Crecent	Crecent	Elongated	Elongated	
Land use pattern - --------------	------------------------------- Inhabitation and Cultivation -----------------------				

Composition/Litho constituents Arranged in probable order of abundance	River bed :-	Quartzite, gneiss, granite, schist, basic, limestone slate and coarse to fine micaceous sand.
	BHT_1 :-	Quartzite, gneiss, granite, schist, slate, basic, limestone and coarse to fine sand.
fine	BHT_2 :-	Quartzite, gneiss, granite, schist, slate and limestone coarse to sand & silt.
	BHT_3 :-	Quartzite, gneiss, granite, schist, limestone and slate very coarse to very fine sand & silt.
	BHT_4 :-	Quartzite , gneiss, granite, schist, limestone, very coarse to Very fine sand and silt.

**** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

(iv) Locality : Ghansali
(30^0 25’ 00” : 78^0 40’ 00”)

Terrace and its Designation

Age	River bed	BHT_1 Holocene	BHT_2	BHT_3	BHT_4
Elevation above MSL (m)	625	641	659	674	691
Geomorphic break (m)	-	16	15	18	17
Elevation above RB (m)	-	16	31	49	66
Slope	-	----------------------- SW – South -------------------- Towards West --------------------------			
Cycle sedimentation -	-- Polycycle -------------------------------- -------------				
Orientation of L -Axes	-	--------------------------- South west ----------------------------- --------- South -----------------			
Plunge of L-Axes -	10^0-20^0NE -- 5-15^0 North ------------------- -------------				
Relative disposition -	Convergent	Convergent	Convergent	Divergent	
Paired / Unpaired -	Unpaired	Unpaired	Paired	Paired	
Nature of scarp -	--------------------------- Curvilinear --------------------------- Linear				
Sedimentary features -	Most graded bedding Cross bedding, Cross lamination Cut &Full features		---------------------------		
Terrace Shape -	----------------- Crecent ----------------- Elongated ill preserved				
Land use pattern -	-------------------------------- Inhabitation and Cultivation ------------------------ --------------				

Composition/Litho constituents Arranged in probable order of abundance

River bed :-	Quartzite, gneiss, granite, schist, meta-volcanic limestone, phyllite, coarse to fine sand.	
BHT_1 :-	Quartzite, gneiss, granite, meta-volcanic, phyllite, slate in the matrix of coarse to fine sand.	
BHT_2 :-	Quartzite, phyllite, slate, limestone, gneiss, schist sand.	
BHT_3 :-	Quartzite, gneiss, granite, slate, phyllite, limestone, coarse to fine sand.	
BHT_4 :-	Quartzite , gneiss, granite, phyllite, slate, limestone, coarse to fine sand.	

**** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

Table 14:- Salient Features Of Fluvial Terraces In The Type Area Of Nandakini Valley.
(i) Locality : Nandprayag (30^0 27’ 22” : 78^0 22’ 48”)

Terrace and its Designation

Age	River bed	N_1 Holocene	N_2	N_3	N_4
Elevation above MSL (m)	1015	1030	1050	1070	1080
Geomorphic break (m)	-	15	25	20	10

Elevation above RB (m) - 15 40 60 70
Slope - -- Towards North West -- ------------------------------------
Nature of surface - -- Depositional ------------------------------------ Erosional
Cycle sedimentation - Section not fully exposed | Unicycle | Polycycle | Section not fully exposed
Orientation of L -Axes - -- NE – SE -------- -----------------------------------
Plunge of L-Axes - 5^0 towards SE | 5^0 to 10^0 towards SE | 10^0 towards SE
Relative disposition - ----------------- Divergent ----------------- Convergent Divergent
Paired / Unpaired - Unpaired | Paired | Paired | Paired
Nature of scarp - Curvilinear | Curvilinear | Curvilinear | Linear
Terrace Shape - ------------------------- Rectangular ------------------------ Semi Circular
Sedimentary features - Graded bedding Cross bedding Lamination and Features | Graded bedding, cross lamination, lamination cut and fill features
Land use pattern - ------------------------------- Inhabitation mainly ----------------------------------- ----------------

Composition/Litho constituents Arranged in probable order of abundance

River bed :- Quartzite, gneiss, granite, schist, phyllite, slate and sand.

N_1 :- Quartzite, gneiss, granite, schist, basic slate, phyllite coarse to fine sand.

N_2 :- Quartzite, gneiss, granite, schist, slate, coarse to fine Sand and silt.

N_3 :- Gneiss, granite, biotite, uncomposed highly wethered schist Slate, light maroon sand, silt and clay.

N_4 :- Gneiss, granite, schist, slate, light to dark maroon clay, silt and sand.

** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.

(ii) Locality : RAJWAKTI
(30^0 28' 05" : 78^0 30' 00")

Terrace and its Designation

	River bed	N_1	N_2	N_3	N_4
Age	Holocene				
Elevation above MSL (m)	1020	1030	1050	1075	1105
Geomorphic break (m)	-	10	20	25	30
Elevation above RB (m)	-	10	30	55	85
Slope	-	-- Towards West ----------- ---------------------------------			
Nature of surface	-- Depositional ------------------------------------ Erosional				
Cycle sedimentation	Section not fully exposed	Polycycle	Section not fully exposed		
Orientation of L-Axes	--- East West ---------------------------- --------------				
Plunge of L-Axes	5^0 towards	East	0^0 towards	North East	
Relative disposition	Convergent	Divergent	Divergent	Divergent	
Paired / Unpaired	Paired	Paired	Paired	Paired	

Nature of scarp	-	Curvilinear	Linear	Linear	Linear
Terrace Shape	-	Cuspate	Rectangular	Semi-Circular	Semi-Circular
Sedimentary features	-	Section not full exposed	Cross bedding graded bedding lamination, cross lamination and cut and fill features	-------	Section not fully exposed ---------
Land use pattern	-	------------------------------ Inhabitation mainly ---------------------------------- ----------------			

Composition/Litho constituents Arranged in probable order of abundance

River bed :- Quartzite, gneiss, granite, schist, slate and sand.

N_1 :- Gneiss, granite, schist, slate, sand and slit.

N_2 :- Quartzite, gneiss, granite, schist, slate, coarse to fine sand and silt.

N_3 :- Quartzite, gneiss, granite, schist, slate, clay, sand and silt.

N_4 :- Gneiss, granite, schist, slate, pink maroon clay, silt and coarse to fine Sand.

** Litho- constituents are arranged in probable order of abundance. The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.

(iii) Locality : Nanala
(30^0 28’ 00” : 78^0 25’ 00”)

Terrace and its Designation

		River bed	N_1	N_2	N_3	N_4
Age			Holocene			
Elevation above MSL (m)		1020	1025	1050	1075	1105
Geomorphic break (m)		-	05	25	25	30
Elevation above RB (m)		-	05	30	55	85
Slope		-	-- Towards NW ------------ --------------------------------			
Nature of surface	- Erosional	---------------------------------	Depositional -------------------------			
Cycle sedimentation	-	-	-	Polycycle	Section not fully exposed	
Orientation of L-Axes	-	-- NW-SE -------------------------------- -----------				
Plunge of L-Axes	-	5^0 towards SE	5^0 towards SE	10^0 towards SE	10^0 towards East	
Relative disposition	-	Divergent	Divergent	Divergent	Divergent	
Paired / Unpaired	-	Unpaired	Paired	Paired	Paired	
Nature of scarp	-	Curvilinear	Linear	Linear	Linear	
Terrace Shape	-	Rectangular	Rectangular	Rectangular	Semi-Circular	
Sedimentary features	-		Graded Bedding Cross Lamination Graded Lamination	Cross bedding lamination cross lamination cut and fill features	Graded bedding cross bedding cross lamination lamination and cut fill	cut fill features
Land use pattern	-	----------------------------- Inhabitation and cultivation ------------------------- ---------------------				

Composition/Litho constituents Arranged in probable order of abundance	**River bed :-**	**Quartzite, gneiss, granite, schist, slate, phyllite and sand.**
	N_1 :-	**Quartzite, gneiss, granite, schist, slate, phyllite and sand**
	N_2 :-	**Quartzite, gneiss, granite, schist, slate and silt.**
	N_3 :-	**Gneiss, granite, schist, slate, clay, sand and silt etc.**
	N_4 :-	**Gneiss, granite, schist, slate, dark maroon clay, silt and sand.**

**** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

Table 15:- Salient Features Of Fluvial Terraces In The Type Area Of Mandakini Valley
(i) Locality : TILWARA (30^0 20' 00" : 79^0 05' 00")

Terrace and its Designation	River bed	MT_1	MT_2	MT_3	
Age		Holocene			
Elevation above MSL (m)		660	700	730	769
Geomorphic break (m)		-	40	30	30
Elevation above RB (m)		-	40	70	100
Slope		-	SW	SW	SW
Nature of surface	-	Depositional	Depositional	Depositional	
Cycle sedimentation	-	Unicycle	Polycycle	Polycycle	
Orientation of L-Axes	-	NNW-SSE	NS	NS	
Plunge of L-Axes	-	5^0 N	5^0 N	5^0 N	
Relative disposition	-	Convergent	Divergent	Convergent	
Paired / Unpaired	-	Unpaired	Paired	Paired	
Nature of scarp	-	Curvilinear	Curvilinear	Curvilinear	
Terrace Shape	-	Semi Circular	Semi Circular	Semi Circular	
Sedimentary features	-	Graded Bedding and Cross Bedding	Graded bedding cross bedding lamination Cross lamination both planner and through type Graded lamination, cut and fill features	Graded bedding cross bedding lamination cross lamination both planner and type. Graded limitation cut and fill features	
Land use pattern	-	------------------------------------Inhabitation and Cultivation -----------------------------			

Composition/Litho constituents	**River bed :-**	**Quartzite, gneiss, granite, schist, basic, limestone, phyllite, slate, sand**
Arranged in probable order of	**MT_1 :-**	**Quartzite, gneiss, granite, schist, basic slate, phyllite, silt, and clay.**
abundance	**MT_2 :-**	**Quartzite, gneiss, granite, schist, basic, slate, phyllite, silt, sand and clay.**
	MT_3 :-	**Gneiss, granite, schist, slate, phyllite, shale, limestone, sand. Silt and clay.**

**** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

(ii) Locality : AGAUSTMUNI (30^0 23' 25" : 79^0 00' 55")

Terrace and its Designation

	River bed	MT_1	MT_2	MT_3
Age		**Holocene**		
Elevation above MSL (m)		**720**	**740**	**775 805**
Geomorphic break (m)		**-**	**20**	**35 30**
Elevation above RB (m)		**-**	**20**	**55 85**
Slope		**SW**	**SW**	**SW SW**
Nature of surface -		**Depositional**	**Erosional**	**Depositional**
Cycle sedimentation -		**Not fully exposed**	**Polycycle**	**Not fully exposed**
Orientation of L-Axes -		**NE-SW**	**NE-SW**	**NE-SW**
Plunge of L-Axes -		**50^0 - 10^0 NE**	**10^0 NE**	**10^0 NE**
Relative disposition -		**Divergent**	**Divergent**	**Divergent**
Paired / Unpaired -		**Unpaired**	**Paired**	**Unpaired**
Nature of scarp -		**Linear**	**Curvilinear**	**Curvilinear**
Terrace Shape -		**Cuspate**	**Rectangular**	**Rectangular**
Sedimentary features -		**Cross Bedding Lamination and Cross Lamination**	**Cross bedding, graded bedding lamination and cross lamination, cut and fill features.**	

Land use pattern - -----------------------------------Inhabitation and Cultivation -----------------------------

Composition/Litho constituents Arranged in probable order of abundance

River bed :- Quartzite, gneiss, granite, schist, basic, slate and phyllite.

MT_1 :- Quartzite, gneiss, granite, schist, slate, phyllite, limestone.

MT_2 :- Quartzite, gneiss, granite, schist, phyllite, slate, shale and sand.

MT_3 :- Quartzite, gneiss, granite, schist, phyllite, slate, shale, silt, clay and sand.

**** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

(iii) Locality : SAURI AND HAT (30^0 24' 30" : 79^0 3' 00")

Terrace and its Designation

	River bed	MT_1	MT_2	MT_3
Age		**Holocene**		
Elevation above MSL (m)		**750**	**765**	**790 810**
Geomorphic break (m)		**-**	**15**	**25 20**
Elevation above RB (m)		**-**	**15**	**40 60**
Slope		**SW**	**SW**	**SW SW**
Nature of surface -		**Depositional**	**Depositional**	**Depositional**
Cycle sedimentation -		**Unicycle**	**Unicycle**	**Polycycle**
Orientation of L-Axes -		**NE-SW**	**NNE-SSW**	**NNE-SSW**
Plunge of L-Axes -		**5^0 NE**	**5^0 NNE**	**5^0 NNE**
Relative disposition -		**Convergent**	**Convergent**	**Divergent**
Paired / Unpaired -		**Unpaired**	**Unpaired**	**Unpaired**
Nature of scarp -		**Curvilinear**	**Curvilinear**	**Curvilinear**
Terrace Shape -		**Semi Circular**	**Elongated**	**Elongated**

Sedimentary features -	**Graded bedding Cross bedding Lamination cross Lamination**	**Graded lamination cross bedding, both planner and through type Lamination cut & fill Features**	**Graded bedding cross bedding lamination cross lamination cut and fill features**

Land use pattern - ----------------------------------Inhabitation and Cultivation ---------------------------

Composition/Litho constituents Arranged in probable order of abundance

River bed :- Quartzite, gneiss, granite, schist, basic, phyllite, slate and micaceous Sand.
MT_1 :- Quartzite, gneiss, granite, schist, slate, phyllite, and sand.
MT_2 :- Quartzite, gneiss, granite, schist, slate, phyllite, limestones.
MT_3 :- Quartzite, gneiss, granite, biotite, schist, slate, phyllite, limestone, Silt, clay and sand.

** **The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

(iv) Locality : BHAGIRATHI/GOVINDGAON (30^0 26' 00" : 78^0 05' 00")

Terrace and its Designation

	River bed	MT_1	MT_2	MT_3
Age		**Holocene**		
Elevation above MSL (m)		**775**	**800**	**830 850**
Geomorphic break (m)		**-**	**25**	**30 20**
Elevation above RB (m)		**-**	**25**	**55 75**
Slope		**-**	**SW**	**SW SW**
Nature of surface -		**Depositional**	**Depositional**	**Depositional**
Cycle sedimentation -		**Not fully exposed**	**Polycycle**	**Polycycle**
Orientation of L-Axes -		**NNW-SSE**	**NNW-SSE**	**NNW-SSE**
Plunge of L-Axes -		**5^0 N**	**5^0 - 10^0 N**	**5^0 - 10^0 N**
Relative disposition -		**Divergent**	**Divergent**	**Divergent**
Paired / Unpaired -		**Paired**	**Paired**	**Paired**
Nature of scarp -		**Linear**	**Linear**	**Linear**
Terrace Shape -		**Elongated**	**Elongated**	**Elongated**
Sedimentary features -		**not fully exposed**	**Graded bedding, cross bedding Lamination, cross laminations.**	

Land use pattern - ----------------------------------Inhabitation and Cultivation ---------------------------

Composition/Litho constituents Arranged in probable order of abundance

River bed :- Quartzite, gneiss, granite, schist, basic, phyllite, slate and sand.
MT_1 :- Quartzite, gneiss, granite, schist, basic, slate, phyllite, shale and sand.
MT_2 :- Quartzite, gneiss, granite, basic, slate, phyllite, limestone, silt Sand and clay.
MT_3 :- Gneiss, granite, schist, basic, limestone, phyllite, slate, shale, clay and silt.

** **The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

(v) Locality : BERHI AND DAMER (30^0 27' 30" : 79^0 05' 00")

Terrace and its Designation

River bed	MT_1	MT_2	MT_3
Age	Holocene		
Elevation above MSL (m)	830	845	860 880
Geomorphic break (m)	-	15	15 20
Elevation above RB (m)	-	15	30 50
Slope	-	South	South South
Nature of surface -	Depositional	Depositional	Depositional
Cycle sedimentation -	Unicycle	Unicycle	Polycycle
Orientation of L-Axes -	NS	NS	NW-SE
Plunge of L-Axes -	5^0 N	5^0 - 10^0 NW	5^0 - 10^0 NW
Relative disposition -	Convergent	Convergent	Linear
Paired / Unpaired -	Unpaired	Paired	Paired
Nature of scarp -	Curvilinear	Curvilinear	Linear
Terrace Shape -	Cuspate	Semi-Circular	Ventricular
Sedimentary features -		Cross bedding Lamination & cross lamination	Graded bedding cross bedding planner and trough type
Land use pattern -	-----------------------------------Inhabitation and Cultivation -------------------- ---------		

Composition/Litho constituents Arranged in probable order of abundance

River bed :- Quartzite, gneiss, granite, schist, phyllite, slate and micaceous sand.

MT_1 :- Quartzite, gneiss, granite, schist, slate, phyllite, shale and sand.

MT_2 :- Gneiss, granite, schist, phyllite, slate, shale and sand.

MT_3 :- Gneiss, granite, schist, basic, phyllite, slate, light maroon silt, and sand.

** **The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

Table 16:- Salient Features Of Fluvial Terraces In The Type Area Of Pindar Valley.

(i) Locality : KARANPRAYAS (30^0 15' 30" : 79^0 13' 00")

Terrace and its Designation

River bed	PT_1	PT_2	PT_3
Age	Holocene		
Elevation above MSL (m)	769	785	805 825
Geomorphic break (m)	-	16	20 20
Elevation above RB (m)	-	16	36 56
Slope	-	NW	NW NW
Nature of surface -	Depositional	Depositional	Depositional
Cycle sedimentation -	Section not exposed	Polycycle	Polycycle
Orientation of L-Axes -	NW-SE	NW-SE	NW-SE

Plunge of L-Axes	-	**5^0 SE**	**5^0 SE**	**5^0 -10^0 SE**
Relative disposition	-	**Divergent**	**Divergent**	**Divergent**
Paired / Unpaired	-	**Unpaired**	**Paired**	**Paired**
Nature of scarp	-	**Linear**	**Linear**	**Linear**
Terrace Shape	-	**Rectangular**	**Rectangular**	**Rectangular**
Sedimentary features	-	**-**	**Graded bedding Cross bedding Lamination and Cross lamination**	**Cross bedding both planner and trough type graded bedding, lamination Cross lamination.**
Land use pattern	-	**----------------------------------Inhabitation and Cultivation ---------------------------**		

Composition/Litho constituents River bed :- Quartzite, gneiss, granite, schist, fossiferous, limestone, phyllite, slate
Basic and sand.

Arranged in probable order of abundance

PT_1 :- Quartzite, gneiss, granite, schist, phyllite, slate, basic sand and silt.

PT_2 :- Quartzite, gneiss, granite, schist, basic, slate, phyllite, shale, limestone, sand and silt.

PT_3 :- Gneiss, granite, schist, phyllite, slate, shale, light to dark maroon sand, silt and clay.

**** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

(ii) Locality : SIMLI (30^0 13' 30" : 79^0 36' 20")

Terrace and its Designation

		River bed	PT_1	PT_2	PT_3
Age			**Holocene**		
Elevation above MSL (m)		**800**	**815**	**835 855**	
Geomorphic break (m)		**-**	**15**	**20 20**	
Elevation above RB (m)		**-**	**15**	**35 55**	
Slope		**-**	**NW**	**NW NW**	
Nature of surface	-	**Depositional**	**Depositional**	**Depositional**	
Cycle sedimentation	-	**Section not exposed**	**Polycycle**	**Polycycle**	
Orientation of L-Axes	-	**NW-SE**	**NW-SE**	**NW-SE**	
Plunge of L-Axes	-	**5^0 - 10^0 SE**	**10^0 SE**	**10^0 SE**	
Relative disposition	-	**Divergent**	**Divergent**	**Divergent**	
Paired / Unpaired	-	**Paired**	**Paired**	**Paired**	
Nature of scarp	-	**Linear**	**Linear**	**Linear**	
Terrace Shape	-	**Rectangular**	**Rectangular**	**Rectangular**	
Sedimentary features	-	**Section not fully exposed**	**Cross lamination Lamination & cut and Fill features**	**Cross bedding Graded bedding graded lamination cross lamination**	
Land use pattern	-	**----------------------------------Inhabitation and Cultivation ---------------------------**			

Composition/Litho constituents River bed :- Quartzite, gneiss, granite, schist, basic, phyllite, shale, and sand.
Basic and sand.

Arranged in probable order of

PT_1 :- Quartzite, gneiss, granite, schist, basic, phyllite, limestone and

		Coarse to fine sand.
abundance	**PT 2 :-**	**Quartzite, gneiss, schist, basic, slate, phyllite, shale, and light to dark brown maroon sand, silt and clay.**
and	**PT 3 :-**	**Quartzite, gneiss, granite, schist, basic, slate, phyllite, sand, silt clay**

**** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

Table 17:- Salient Features Of Fluvial Terraces In The Type Area Of Dhauli Ganga Valley.
(i) Locality : TAPOBAN (30^0 29' 00" : 79^0 37' 30")

Terrace and its Designation

	River bed	DGT$_1$	DGT$_2$	DGT$_3$
Age		**Holocene**		
Elevation above MSL (m)		**1995**	**2010**	**2018 2024**
Geomorphic break (m)		**-**	**10**	**8 6**
Elevation above RB (m)		**-**	**10**	**18 24**
Slope		**-**	**SW**	**SW SW**
Nature of surface	**-**	**Depositional**	**Depositional**	**Depositional**
Cycle sedimentation	**-**	**Polycycle**	**Polycycle**	**Section not exposed**
Orientation of L-Axes	**-**	**SW**	**SW**	**SW**
Plunge of L-Axes	**-**	**N**	**NE**	**NE**
Relative disposition	**-**	**Convergent**	**Convergent**	**Divergent**
Paired / Unpaired	**-**	**Unpaired**	**Unpaired**	**Paired**
Nature of scarp	**-**	**Curvilinear**	**Curvilinear**	**Linear**
Terrace Shape	**-**	**Semi-Circular**	**Elongated**	**Elongated**
Sedimentary features	**-**	**Graded bedding Lamination, cut & fill**	**cross**	**Section not exposed lamination features**
Land use pattern	**-**	**-----------------------------------Inhabitation and Cultivation -------------------- ---------**		

Composition/Litho constituents	**River bed :-**	**Quartzite, gneiss, biotite, schist, muscovite, schist, slate, chlorite Schist, and coarse to fine sand.**
Arranged in probable order of fossiliferous boulders	**DGT$_1$:-**	**Gneiss, granite, biotite, schist, chlorite, schist, of limestone and quartzite, coarse to fine sand.**
abundance of	**DGT 2 :-**	**Gneiss, granite, biotite, chlorite, phyllite, fossiliferous boulders limestone, and quartzite, coarse to fine sand.**
fossiliferous,	**DGT 3 :-**	**Gneiss, granite, biotite schist, phyllite, slate, limestone, Quartzite and limestone with very coarse to very fine sand.**

**** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

Table 18:- Salient Features Of Fluvial Terraces In The Type Area Of Bal Ganga Valley.
(i) Locality : UPSTREAM OF GHANSALI (30^0 25' 00" : 78^0 40' 00")

Terrace and its Designation

	River bed	BGT$_1$	BGT$_2$	BGT$_3$	
Age		Holocene			
Elevation above MSL (m)	720		725	735	742
Geomorphic break (m)	-		5	10	7
Elevation above RB (m)	-		5	15	22
Slope	-		SW	SW	SW
Nature of surface -	Depositional		Depositional	Depositional	
Cycle sedimentation -	Polycycle		Polycycle	Polycycle	
Orientation of L-Axes -	SW		SW	SW	
Plunge of L-Axes -	5^0-10^0 (Average towards north)				
Relative disposition -	Convergent		Divergent	Divergent	
Paired / Unpaired -	Mostly unpaired		Mostly unpaired	Mostly unpaired	
Nature of scarp -	Curvilinear		Curvilinear	Curvilinear	
Terrace Shape -	Crecent and Elongated			Crecent and Elongated	Crecent and Elongated
Sedimentary features -	Graded bedding, lamination and cross lamination				
Land use pattern -	------------------------------------Inhabitation and Cultivation ---------------------------				

Composition/Litho constituents River bed :- Mostly Quartzite, gneiss, granite, schist, slates, very coarse to fine Sand and silt.

Arranged in probable order of coarse to tine abundance

BGT$_1$:- Mostly Quartzite, gneiss, granite, schist, slate, very sand and silt.

BGT$_2$:- Quartzite, gneiss, granite, muscovite, and biotite, schist, limestone, very coarse to fine sand silt.

BGT$_3$:- Quartzite, gneiss, granite, schist, slate, coarse to fine sand and silt.

**** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

Table 19:- Salient Features Of Fluvial Terraces In The Type Area Of Madheshwar Ganga Valley

(i) Locality : UPSTREAM OF OKHIMUTH (30^0 31' 30" : 79^0 35' 30")

Terrace and its Designation

	River bed	MDT$_1$	MDT$_2$	
Age		Holocene		
Elevation above MSL (m)	950		962	970
Geomorphic break (m)	-		12	08
Elevation above RB (m)	-		12	20
Slope	-		---------------------------------- South East ----------------------------------	
Nature of surface -	Depositional		Depositional	
Cycle sedimentation -	----------------------- Section not fully exposed ---------------------------			
Orientation of L-Axes -	----------------------- Section not fully exposed ---------------------------			
Plunge of L-Axes -	----------------------- Section not fully exposed ---------------------------			
Relative disposition -	Convergent		Convergent	
Paired / Unpaired -	Unpaired		Unpaired	
Nature of scarp -	Curvilinear		Curvilinear	

Terrace Shape - ------------------------ Crecent to Semi Circular ----------------------------
Sedimentary features - ------------------------ Section not fully exposed ----------------------------
Land use pattern - -----------------------------------Inhabitation and Cultivation --------------------
----
Composition/Litho constituents River bed :- Gneiss, granite, muscovite, schist, biotite, schist, slate, coarse To fine sand.
Arranged in probable order of MDT $_1$:- Gneiss, granite, biotite, schist, muscovite, quartzite, slate, coarse to fine sand.
abundance MDT $_2$:- Gneiss, granite, biotite, schist, muscovite, schist very coarse to fine sand and sits.

**** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**
The salient features of the terrace are tabulated in Table No. 20.

Table 20:- Salient Features Of Fluvial Terraces In The Type Area Of Berhi Ganga Valley.
(i) Locality : GORIGOAN (30^0 23' 00" : 79^0 25' 10")

Terrace and its Designation

	River bed	**BRT$_1$**
Age		**Holocene**
Elevation above MSL (m)	**720**	**728**
Geomorphic break (m)	**-**	**8**
Elevation above RB (m)	**-**	**8**
Slope	**-**	**South West**
Nature of surface -	**Depositional**	
Cycle sedimentation -	**Section not fully exposed**	
Orientation of L-Axes -	**SSW**	
Plunge of L-Axes -	**Towards North**	
Relative disposition -	**Convergent with respect to river course**	
Paired / Unpaired -	**Unpaired**	
Nature of scarp -	**Curvilinear**	
Terrace Shape -	**Section not fully exposed**	
Sedimentary features -	**Section not fully exposed**	
Land use pattern -	**Inhabitation and Cultivation**	

Composition/Litho constituents River bed :- Gneiss, granite, slate, quartzite, phylites, limestone Schist and coarse to fine sand.
Arranged in probable order of BRT $_1$:- Quartzite, phyllite, limestone, gneiss, granite, schist, slate, and Coarse to fine sand.
abundance

**** The fabric elements of river terraces range in size from boulder to small pebble. The finer clastics comprise of very coarse to very fine sand, silt and clay. These rock fabrics are generally subrounded to well rounded and mostly spherical, oblate, prolate and bladed in shape.**

Table No. 21:- Evolution Of Quaternary Terraces In Upper Ganga Basin, Garhwal Himalaya, U.P.

Age	Environments	Possible Cause	Phase of Aggradation / Degradation	Alaknanda	Bhagirathi	Bhilangna	Nandakini	Mandakini	Pindar
-------------- Holocene ----------------	**---- Fluvial Environment ---**	**Tectonic / Climatic / Eustatic Changes**	**Aggradation / Degradation**	**AT_0**	**BT_0**	**BHT_0**	**NT_0**	**MT_0**	**PT_0**
				Simultaneous processes of erosional / depositional in progress					
			Aggradation / Degradation	**AT_1**	**BT_1**	**BHT_1**	**NT_1**	**MT_1**	**PT_1**
				Riverine depositional processes in progress					
			Aggradation / Degradation	**AT_2**	**BT_2**	**BHT_2**	**NT_2**	**MT_2**	**PT_2**
				Riverine depositional processes in progress					
			Aggradation / Degradation	**AT_3**	**BT_3**	**BHT_3**	**NT_3**	**MT_3**	**PT_3**
				Riverine depositional processes in progress					
			Aggradation / Degradation	**AT_4**	**BT_4**	**BHT_4**	**NT_4**		
				Riverine depositional processes in progress					
			Aggradation / Degradation	**AT_5**	**BT_5**				
				Riverine depositional processes in progress					
			Aggradation / Degradation	**AT_6**					
				Riverine depositional processes in progress					

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