QUATERNARY TERRACES OF DIFFERENT DOMAINS OF ALAKNANDA & ITS TRIBUTATIES, BEHAVIOUR OF STATISTICALCAL PARAMETERS DOWN THE CURRENT IN BADRINATH _RESHIKESH SECTION, GARHWAL HIMALAYA, UTTTRAKHAND STATE IN

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ABSTRACT

The sedimentological study in Alaknanda and Bhagirathi valley in upper Ganga basin has been attempted in parts of de Uttarkashi,Chamoli, Pauri and Tehri districts in parts of QA sheet 53Jand 53 N on 1:50000 scale of Garhwal Himalaya U.P; presently known as Uttrakhand State of Union of India. The area of Upper Ganga basin consisting of Alaknanda,Bhagirathi,Bhilangna, Nandakini, Mandakini, Pindar, Dhauli- Ganga Bal- Ganga , Madhmeshwar Ganga and Berhi Ganga The Alaknanda is chracterised by six terraces followed by Bhagirathi with five terraces , Bhilangna Nandakini four terraces Mandakini /Pindar/Dhauli-Ganga /Balganga three terraces , Madhmshwar Ganga two terraces and Berhi Ganga one terrace, amidst these Alaknanda is trunk stream and others are tributaries.

The Alaknanda is the trunk stream of Ganga system, it drains the eastern part of the area of study .The rocks of Alaknanda valley and adjoining area consist of three units viz Central Cryastalline, Garhwal Group and Dudatoli Groups which from north to south are separated by thrust or fault. The Central Crystalline Group in this area consist of of northerly dipping sequence of Kyanite schist,Garnet mica schist quartzites and para amphibolites of Tugnath formation, it is intruded by granite at Ragsi.The main Central Thrust seprates it from Garhwal Groupof rocks.The Dudatoli Group is represented Pauri Phyllite and Kirsu Quartzite which forms the northern limb of Dudatoil syncline. The north Almora Thrust makes it boundary with Garhwal group. The later is divisiable in to Rudraprayga, Lamri, Chamoli and Gawangarh and Patrali Formation which occurs in normal stratigraphic order. It is intruded by biotite granite by biotite graninte at Nainidevi and Mohankal, with tourmaline granite around Chirpatikhal and also by basic intrusive. The Rudraprayg, Lameri and Chamoli formations are equivalent to Uttarkashi Shyalnan and Nagnithhank Formation respectively in Bhagirathi valley.

The Garhwal Group has been subjected to three phases of tectonic deformation. The south east to southerly plunging folds such as Marithanasa and Pingapani synclines Karanprayg anticline were developed during the second phase of movements. The Alaknada fault which cuts off set of the formation and earlier structures between Sunala is the strike slip fault in western part, appears to be the youngest elements.The impact of this fault is manifested in alignment of river terraces and landscape profile in Alaknanda valley. Geologically, the Bhagirathi valley and adjoining areas comprises of four distinct units namely from north to south the Central Crystalline Group , the Deoban Group the Simla Group,and Krol belt rock separating from one another by thrust or faults. The main Central Thrust passing through Sainj upstream Uttaarkashi in northern part brings the northerly dipping crystalline rocks in sharp contact with under lying Deoban Group (Garhwal Group) sedimentries which comprises a lower Deoban Formation of Phyllite, slate Meta basics, minor quartzite and lime stone, the middle Deoban formation of lime stone and upper Deoban formation of Quartzite and basics. The southern contact of Deoban Group is faulted one with comprising mainly siltstone, greywacks and slates dipping south

This fault called Sringar Nalupani fault is of fundamental nature. In the southern and eastern part of the area this fault marks the contact between Deoban and Chandpur formation. In the western part south heading Ton Thrust separates the underlying Chanpur formation from the underlying Simla slates which shows abundant development of slump balls rod etc. indicating syndepositional disturbances in the basin of sedimentation; while in Chanpur formation, is manly argillaceous, becoming arenaceous towards the top. The Tons thrust passes through Laluli in Nagun Gad and is probably truncated by Tehri Nalupani fault at Chandpur in Bhagirathi valley.

The study of geology ,geomorphology, Quaternary terraces and landscape profile section revealed that there is sharp curvilinear break in morphogenetic expression of the area, North of Wazri in Jamuna valley, North of Uttarkashi in Bhagirathi valley, around Tugnath and Chamoli and South of Joshimuth in Alaknanda valley, which is significant element, appears to be due to horizontal movement of a sub - tectonic plates towards south., It may be causative factor in dislocation in tectonic ecology of the area, related to recent micro shocks in Joshimuth in Niti and Hellong area, mass failure of landscape profile, landslide and mass wasting activities and other natural hazards; it is matter of serious concerned and needs further attention.

The area genetically comprised of terraces of three domains, viz. Glacial, Fluvio-glacia and Fluvial which represent distinct environment of sedimentation of Pleistocene, late Pleistocene and Holocene time during Quaternary period. The Glacial terraces are identified at an average elevation of 1150 m above MSL, the fluvio-glacial terraces at an average elevation of 975m above MSL and fluvial terraces at an average elevation between 650 to 900 m above m.s.l, amidst these sdimentological studies of Alaknanda and Bhagirathi terraces in type area is attempted in to understand the nature of erosional and depositional processes, sedimentary pattern, behavior of transporting agencies, load characteristics, current capacity, energy condition to decipher over all history of Quaternary sedimentation in these valleys inI increasing antiquity.

The average mean size of sediments of terraces of glacial domain is 0.09 Ø (Coarse sand). It varies from -2.81 Ø to 2.8 Ø i.e. the sediment consist of very coarse sand to fine sand. The maximum value of (MZ) is -2.81 Ø near the origin of the river and minimum 2.8 Ø near the outer limit of these terraces around Chamoli. The (MZ) shows sharp decrease in size in Badrinath and Vishnuprayag, section corresponding to the steep slope of river. Down the stream Vishnuprayag although it decrease in its value but display strong variation in size, which is attributed to the mixing of sediments brought by the sub-glacier joining the main Alaknanda at various points. It is a measure of sorting which reflects the consistency in the energy level of depositing medium. In respect of glacial terraces the average standard deviation is 3.34 Ø (very poorly sorted). It varies from 2.00 Ø to 4.30 Ø i.e. the sediments are poorly sorted to extremely poorly sorted. The sediments of these terraces are extremely assorted and are heterogonous in nature and multi source of their derivation.. The average (SKI) for glacial sediments is 0.064 Ø i.e. the sediments are negative skewed. It ranges from -0.450 Ø to + 0.52 Ø i.e. the sediment are negative skewed to positive skewed, which indicate the tendency of gradual decrease in value of (SKI) in upstream direction as result of retreat of glacier and decrease in the transport capacity. The 56% of the sample shows the negative value and 44% positive value. The sediments are very positive skewed to very negative skewed which seems to be due to mixing of sediments brought by various glaciers. The sediments down the stream of Badrinath have the strong tendency to be positive skewed.. The value of (KG) in the sediments of glacier terraces is highly variable. The average value is 0.716 Ø (platykurtic); whereas it varies from 0.49 Ø to 1.10 Ø (very platykurtic to leptokurtic).. In Alaknanda valley along the stretch of 110 km between Chamoli and Badrinath there is general uniformity in (KG) value except in the confluence area.

The average mean size of sediments of fluvio-glacial domain is 2.15 Ø (medium sand). It varies from -2.53 Ø to 3.12 Ø i.e. the sediments consist of very coarse to very fine sand. The size distribution of these deposits in the study area is extremely irregular and erratic. The sediments near the outer edge of glacial deposit downstream of Chamoli ranges 0.75 Ø to 0.50 Ø i.e. coarse to very coarse sand which constantly show decrease in (MZ) along the stretch of 30 km up to Karanprayag. The sediments between Chamoli and Karanprayag along 45 km show range of order of 1.25 Ø to 2.75 Ø with local variation. The sudden rise in (MZ) is noticed around Nandaprayag and downstream and downstream of confluence of Alaknanda and Nandakini (MZ) values are of order of 0.50 Ø to 0.15 Ø, which indicates the intensive mixing of sediments brought from the flash stream resulting from the retreating glacier at different point in the valley..The standard deviation of fluvio-glacial sediments varies from 0.95 to 2.50 Ø i.e. the sediments are poorly sorted to very poorly sorted. The average standard deviation is 1.563 Ø (extremely poorly sorted). Out of 50 samples 8% are moderately sorted, 10% poorly sorted and 32% are very poorly sorted. The sediments near the source area conspicuously exhibit poor sorting and show significant improvement down the stream with local variation. As a whole the sediments are poorly sorted to very poorly sorted and heterogeneous in nature.

The fluvio glacial sediments show skewness ranging from -0.48 Ø to + 0.97 Ø i.e. the sediments are skewed very negative to skewed very positive. The average of (SKI) is 0.078 Ø i.e., the sediments are fine skewed. Out of the total samples of these terraces 56% are skewed positively, 16, skewed positive and 22, are skewed very negative. The assemblage of variable value of (SKI) suggests the heterogeneous association of the sediments ranging from fine sand to gravel size. The (SKI) value in general increase downstream with occasional variation. It is perhaps due to repeated reworking of the sediments towards downstream side by flash stream resulting from the glacier.The average (KG) is 1.316 (leptokurtic). It ranges from 0.76 Ø to 1.52 Ø (platykurtic to very leptokurtic) among these 75% of the sample fall in very platykurtic class 47.50 (mesokurtic) and 45, (leptokurtic). The assemblage of these different classes of kurtosis suggests the dominance of coarse sediments (Folk & Ward, 1957). Most of the samples between Chamoli and Karanprayag section along the starch of about 45 km show the Kurtosis value ranging between 0.90- 1.20 Ø except in the area around Nandaprayag Nagrasu, where the sedimentation is perhaps affected by lateral mixing of sediments brought by the sub-glaciers. It seems that sediments were transported and deposited in the oscillating kinetic condition.The average mean size for the sediments of terraces of fluvial of Alaknanda is 2.458 Ø. The maximum value of (MZ) is -0.491 Ø is noticed near Karanpravag while minimum 4.545 Ø at Deopravag, near the confluence of Alaknannda and Bhagirathi River. The (MZ) shows the significant consistency in its value in the first stretch of about 35 km between the Karanprayag and Nagrasu, corresponding to the flattered and gentle slope of the river bed. Down the stream of Nagrasu for about 75 km up to Deoprayag (MZ) sharply decreases perhaps due to sharp change in bed slope of Alaknanda. In this section (MZ) strongly fluctuates around Kaliyasour, Srinagar and Kirtinagar for about 25 km which correlated to the sudden convexity in the river bed due to Neotectonic activity in the vicinity of Srinagar fault/ North Almora thrust, which traverses across the Alaknanda around Kaliyasour.It seems that the mean size of fluvial sediments sharply follow the bed slope, pointing to exponential longitudinal profile, thus decrease in (MZ) in the downstream of the Alaknanda is result of decrease in both transporting capacity and velocity of the river towards the later phases of sedimentation in the valley.

The average standard deviation of sediment is 0.691 Ø (moderately sorted) and it ranges from 0.15 Ø to 1.52 Ø i.e. the sediments are very well sorted to poorly sorted. In the upper Alaknanda, it shows consistency in value down the current except around, Karanprayag and Rudraprayag, where Nandakini Pindar and Mandakini joined Alaknanda respectively. The variation in and around these places appears to be due to mixing of sediments brought by these tributaries. The sharp improvement in sorting is noticed downstream of Rudraprayag upto Srinagar which seems to be related with the repeated reworking of sediments and slope element. The sudden decline in sorting coefficient in the stretch of about 15 km between Srinagar and Kirtinagar appears to be due to either the non-transport of larger grain down current or due to loss of bed slope of Alaknanda in this segment of valley. The significant increase in sorting in down current of Kirtinagar indicates cyclic reworking of sediments appears due to re-activation of channel in this part of valley.The average (SKI) of fluvial sediments is 0.00281 Ø It ranges from -0.99 Ø to 0.99 Ø i.e. the sediments are coarse to fine skewed. The (SKI) exhibits tendency of gradual increase in value downstream with local variation. This suggests relative increase of fine grains, down the stream. The sediment upstream of Karanprayag is negative skewed perhaps due to mixing of sediments of fluvio glacial origin.The kurtosis of fluvial sediments of Alaknanda is highly variable; it ranges from 0.72 Ø to 1.72 Ø (leptokurtic) and an average value 1.264 Ø (platykurtic to very (leptokurtic). The average values suggest the fluctuation in the energy condition of the channel system. The mean value of kurtosis revealed the more intensive sorting of central part of size distribution curve than the tails. Along the course of Alaknanda in Nadaprayag and Deoprayag section for a distance of about 75 km except local variation around Karanprayag, Rudraprayag, there is strong tendency in increase of kurtosis value downstream.

The longitudinal profile of Alaknanda River and its terraces of various domain is overall concave, smooth and gentle, except in the area between Karanprayag, Dharkot, Rudraprayag and Kaliasour, where it is slightly upward convex. The gradient of the river between Chamoli and Karanprayag is 1:6.6, between Karanprayag to Rudraprayag 1:2.25, and between Rudraprayag and Srinagar is 1:1. The average gradient of terraces AT1, to AT6, between Karanprayag and Dharkot and Dharkot and Kaliasour is 1:2.29, 1:1.66, 1:1.87, 1:2.20 and 1:1.25, respectively. The upward convexity in the area as mentioned above indicates some differential up warping of some of the terrace blocks possibly due to some movements along the Srinagar-Tehri Fault/Alaknanda Fault (Sinha & Khan .1975, Khan 1981).The profile of terraces of glacial domain is restricted up Chamoli and is of hanging in nature , whereas of fluvio-glacial terraces mostly confined to the upstream of Karanprayag, it pinches out downstream against the terraces of fluvial domain, thereby indicating an intensive down cutting of the valley floor by Alaknanda through cyclic rejuvenation consequent to recession of in post Pleistocene time. The profile of glacial terraces demonstrate intensive dissection of terraces and isolated pockets and lenses of occurrence at higher level in the valley and profile is of is of hanging in nature, whereas of fluvio- glacial is of suspended in nature and suddenly abuts up stream against the profile of glacial terraces and downstream against the profile of fluvial terrace. Down the current profile of fluvial terraces display consistency and and smoothness down the current. The profile of fluvio-glacal terraces represent transitional phase of sedimentation and major in Quaternary time the valley.

The longitudinal profile of Bhagirathi is over all cancave except in the upper reaches between Seansu and Bhatwari, where the upward convexity in the alternate segment is very conspicuous. The upward convexity and development of nick points, corresponds to major tectonic elements, Main Central Thrust (Khan et.al. 1982 1988). Srinagar Nalupani fault and Tons thrust in the area. The gradient of the channel bed in upper Bhagirathi in Bhatwari Uttarkashi section is 1:1.98, in Uttarkashi Dharasu section 1:1.75, in Dharasu-Tehri 1:1.55 and Tehri and Devprayag 1:1.20. The profile of domain of glacial terraces extends up to Gagnani and Fluvio-glacial terraces up to Naturi and down the current profile Fluvial terraces is gentle and smooth and in conformity of river bed. The profile of glacial terraces is of hanging in nature, whereas of fluvio- glacial is of suspended in nature and fluvial display consistency and regularity down the current. The profile of fluvio-glacal terraces represent transational phase of sedimentation in the valley.

The study of Statistical parameters and their correlation with various Thrust, fault, lineament and longitudinal profile of Alaknandaand its tributaries,revealed that there is strong impact and influence of tectonic and Neotectonic activity on Quaternary sedimentation in the area

1.0.0 INTRODUCTION

The Geological and sedimentological study in Alaknanda and its tributaries has been attempted first time 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 / 1:50000 scale has been 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 is 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)

1.1.0 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 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) (Khan, 1974, 2022,2022, 2023). have carried out geological and geomorphological and sedimenological studies in parts of Alaknanda,Bhagirathi,Bhilangna, Nandakini, Mandakini, Pindar, Dhauli- Ganga Bal- Ganga , Madhmeshwar Ganga and Berhi Ganga.The present work is part of comprehensive study carried out about two decade as part of official assignment (1972 to1981) of geological survey of India.

1.2.0 Present work

The present paper is an attempt to trace integrated evolution of fluvial terrace their stratigraphy, their correlation and sedimentological aspects in type area of Alaknanda and Bhagirathi 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). (Table No_1 &_2)

2.0.0 QUATERNARY GEOLOGY

Quaternary deposits of Alaknanda and its tributaries, sequence of terraces and valley development and stratigraphyt in upper Ganga Basin (Khan 1981) is described below:

2.1.0 Glacial Terraces:

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

In Alaknanda valley the occurrences of these terraces are noticed around Chamoli, Pipalkoti, Marwari, Pandukeshar, Hanuman Chatti, Joshimuth and Badrinath. In the vicinity of Badrinath, four levels of the glacial terraces (lateral Moraine) have been identified, besides the terminal moraine and cirque moraine. These terraces on left flank of Vishnu Ganga constitute stepped sequence representing the former levels of valley floor. Each segment of this terrace is separated by ill-preserved and highly dissected scarp, which have mostly subdued sharpness and convex slopes due to prolonged erosion and debris slides subsequent to their deposition in the valley.

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

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

The glacial terraces consist of heterogeneous assemblage of sub angular to angular, unsorted, unstraitified rock fragments ranging from big boulders to small pebbles in size predominantly of gneiss, granite, quartzite and highly weathered biotite muscovite and chlorite schist in the matrix of very coarse to fine sand, silt and clay. These rock clastics are largely angular, very poorly sorted; display isotropic imbrications pattern and are devoid of bedding.

The fine sediments comprise of light smoky coarse to fine sand with appreciable amount of mica flakes; light to dark maroon silt and clay, light brown coarse sand with sub-ordinate amount of silt and dark red and yellow sand with silt. The sand matrix contain fairly good amount of quartz and feldspar grains and loosely composed mica flakes. These sediments around Chamoli, Joshimuth and Hanuman

Chatti in Alaknanda valley display lamination and cross lamination indicative of trough like sedimentation which might have been formed by chocking of the valley during the glacier advance in Pleistocene time.

2.2 Fluvio-glacial Terraces:

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

These are characterized by sub angular to sub rounded boulder, cobble, pebble of quartzite, gneiss granite, slate and decomposed highly weathered biotitic, muscovite and chlorite schist in the matrix and coarse to fine sand, silt and clay. Although the sediments of these terraces are similar in texture and composition to glacial terraces, these exhibit entirely different order of sedimentary pattern and sediment character. In contrast to the glacial terraces, these sediments display moderate degree of sphericity roundness and sorting and show preferred orientation pattern. The ill-preserved sedimentary features and long interval cyclic development of bedding is also conspicuous. These associated diagnostic sediment characters, sedimentary features and disposition of these deposit indicate an intermittent and rapid reworking of the sediments from the glacial front subsequent to the melting of glacier during the late Pleistocene times.

2.3.0 Fluvial Terraces:

The fluvial terraces or alluvial topographic benches of Alaknanda and its tributaries form the prominent Quaternary landscape in the valley breaking the monotony of vast rugged hilly tract. These terraces are formed by a combined intermittent process of aggravation and degradation in the valley associated with different phase of sedimentation of the fluvial domain. As such these 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 1975, Khan 1981).

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

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

The sediments of these terraces are mostly look 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.

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Table 1:- Stratigraphy Of Quaternary Deposit In Upper Ganga Basin, Garhwal Himalaya U.P.

Age	Quaternary	Environment of	Geomorphic land	Composition

	Formation	sedimentation	forms	
	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 2:- Stratigraphy of Quaternary terraces and stages of valley development in Upper Ganga basin, Garhwal Himalaya U.P. India.

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

	I	Alaknanda terraces	AT_1 to AT_3

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

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

2.4.0 The Fluvial terraces of Alaknanda Valley

The Alaknanda originates at a height of 3641 meters below Bala Kun peak 16 km. upstream of Badrinath form the two glaciers of Bhagirath Kharak and Satopanth. The two glaciers rise from the eastern slopes of Chaukhamba (7140 Meters) peak, Badrinath and its satellite peaks.

These peaks separate the Gangotri group of glaciers in the west. The major portion of the Alaknanda basin falls in Chamoli district from its source upto Hellang (58 Km), the valley is treated as upper Alaknanda valley. The remaining part of the area is known as lower Alanknanda valley. While moving from its source, the river flows in a narrow deep gorge between the mountain slopes of Alkapuri, from which it derives its name. All along its course, it drains with its tributaries. Saraswati joins the Alaknanda 9 Km downstream from Mana, .Khilrawan Ganga join it below the Badrinath shrine and Bhuynder Ganga below Hanuman Chatt. It is 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 Bhagirathi at Devprayag. It is further joined by numerous other tributaries in its traverse in Himalaya till it finally debouches in the intermountain 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 has formed six prominent regional terraces AT1-AT6 in the valley. 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 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. 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.

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 glacial terraces.

The longitudinal profile of Alaknanda River and its terraces of different domain is based on the leveling carried out in the different section in the valley. The shape of the profile is overall concave, smooth and gentle, except in the area between Karanprayag, Dharkot, Rudraprayag and Kaliasour, where it is upward convexity. The gradient of the river between Chamoli and Karanprayag is 1:6.6, between Karanprayag and Rudraprayag it is 1:2.25, and between Rudraprayag and Srinagar is 1:1. The average gradient of terraces AT_1, to AT_6, between Karanprayag and Dharkot and Dharkot and Kaliasour is 1:2.29, 1:1.66, 1:1.87, 1:2.20 1:35 and 1:1.25, respectively. The upward convexity in the river bed as mentioned indicates some differential up warping of rock blocks due major thrust/ fault in the area. It indicates some recent movements along the fault and thrust / traversing the area (Srinagari Fault /Alaknanda Fault and others. (Sinha et.al.1975, Khan 1981).

The profile of glacial and fluvio-glacial terraces mostly confined to the upstream of Karanprayag. It pinches out downstream against the terraces of fluvio-glacial domain and fluvial domain down the stream, thereby indicating an intensive down cutting of the valley floor by Alaknanda through cyclic rejuvenation in order to achieve the base level, consequent upon to recedes of glacier, due to major climatic changes in post Pleistocene time. (Plate No _3).

2.5.0 The 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. It 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 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. 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. (Khan, 1974, 2022, 2023).

The longitudinal profile of Bhagirathi is over all concave except in the upper reaches between Seansu and Bhatwari, where the upward convexity in the alternate segment is very conspicuous. The upward convexity and development of nick points, corresponds to major tectonic elements, Main Central Thrust (Khan et.al. 1982). Srinagar Nalupani fault and Tons thrust in the area. The gradient of the channel bed in upper Bhagirathi in Bhatwari Uttarkashi section is 1:1.98, in Uttarkashi Dharasu section 1:1.75, in Dharasu-Tehri 1:1.55 and Tehri and Devprayag 1:1.20. The profile of terraces also follows the channel profile.

The type development of terraces BT_1, to BT_5, is seen in Uttarkashi and Tehri section, in the upstream of Uttarkashi. The thickness of terraces squeezed out and about two kilometers upstream of Maneri where the fluvial terraces are not traceable. In the upstream Delsaur and Gagnani the development of fluvio-glacial terraces are seen. The profile of fluvio-glacial terraces is of suspended in nature, 1t pinches out upstream against the glacial terraces and downstream against the fluvial terraces and represent the transitional phase of sedimentation in the valley (Sinha& Khan et.al.1975).

In lower Bhagirathi in Tehri and Devprayag section Bhagirathi descend down through very tight valley and deep gorges, as such the development of terraces is very scanty, except in the few meandering loops. There are few breaks and scar and relict rock cut terraces in the valley flanks. These breaks represent the former levels of valley floors corresponding to major terraces of Bhagirathi.

2.6.0 The Fluvial terraces of Bhilangna 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, are 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 BHT3 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 2022, 2023). The total average thickness of these terraces is about 55 m whereas the relative thickness is 16, 15, 18, 16 m respectively.

The longitudinal profile of Bhilangna is over all concave and gentle. The gradient of terraces and river is 1:120. The terraces (BHT_1, to BHT_4), are well developed between Ghansali and Tehri, the type development seen at Pilichi, Asena, Dewal and Tebri. These terraces have a little lesser gradient than the channel which indicates that presently the river is slowly undercutting its bed. There is significant reduction in the gradient of terraces between Dewal and Asena, the gradient being slightly more towards both upstream and downstream. This appears to be related with Neotectonic movement along the Srinagar Nalupani fault (Sinha & Khan et.al.1975), which runs oblique to the river through Dewal or along the minor fault between Dewal and Asena running parallel to the river.

2.7.0 The Fluvial terraces of Nandakini Valley

The Nandakini, rises from Semudra Glaciers drainage the western slopes of Trishul mountains (3660 m) in the Central Himalaya. It 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 environment, 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 in mutual relation, whereas NT2 and NT1, have convergent relation. The NT4 and NT3 are mostly cyclic in nature and NT1 is 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 is 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 phases of river sedimentation. The full sequence of terraces NT1- NT4, are observed between elevation of 1080 to 1100 m above m.s.l The total thickness of fluvial terraces in the valley is 60 m whereas the average relative thickness of individual terraces 10, 20.25, 23.21 and 22.40 respectively. ((Khan, 1974, 1975 2022, 2023). .

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 profile of fluvial terraces in general follows the profile of present day channel. It appears that Nandaldni has adjusted its course along some weaker planes during upraise of head ward ends during the Holocene times (Khan 1981).

The gradient of river bed between Nanala and Nandprayag is 1:0.55 and 1:2.77 respectively. Between Nanala and Ghat and around Chamtali there is a sudden fall in the bed slope indicating some up warping neotectonic activity in the area in recent past.

The profile of fluvio-glacial terraces is suspended in nature; it pinches out upstream against the terraces of glacial and downstream against the terraces of fluvial domain and represents the transitional phase of sedimentation in the valley.

The profile of glacial terraces is restricted upstream of Nanala, it is mostly dissected and discontinuous in nature and thereby indicating extensive erosion of these terraces by renewed depositional activities subsequent to the recede of glacier in post-Pleistocene times

2.8.0 **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 conspicuous embraces 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. (Khan, 2022, 2023)

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 Ghatti 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 1988), caused by recent movement and neotectonic along some lineaments traversing across in valley.

The fluvial terraces generally have uniform thickness and gradual gradient in Agasmuni and Rudraprayag section, whereas upstream of Agasmuni it is considerably reduced. The average gradient of these terraces between Agasmuni and Rudraprayag 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 an intermediate stage 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 Agastmuni, in between Kund Chatti and Bhatwari it has gradients of 1:9.33, and in between Bhatwari and Augustmuni is 1:92.

2.9.0 **The Fluvial terraces of Pindar Valley**

The Pindar rises from Milamand Pindar glacier from the Nandadevi group 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.The Pindar downstream of Nalgaon the width of valley broadens out to the range from 670 to 850 m.. ((Khan, 1974, 1975 2022, 2023).

In Pindar valley between Theralli - Simli and Karanprayag three prominent regional terraces have been identified. These are designated as PT1, to PT3. The 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 were 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 general shape of profile of Pindar 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 some up lift along lineaments traversing the area. At places it is also assumed to be due to good competence of bed rock constituting the river bed which is still under active cutting. The convexity in the channel profile in lower Pindar deposition of coarser material in the river bed by tributaries joining Pindar the trunk stream in the lower segment of valley. The association of innumerable channel braids under loading of Pindar is perhaps due to loss of bed slope and low energy condition. The convexity in a river profile in upper segment in catchment area related to recent movements along the lineaments traversing the area which have affected Quaternary land form and various terrace block and tilt in older terraces in Pindar valley (Khan 1974 and 1975)

2.10.0 The Fluvial terraces of Dhauli Ganga Valley

The river Dhauli Ganga rises from the Nitti Pass at about 5070 meters. Its lies between the Kamet groups of peaks in the west and Nandadevi group in the east. The Dhauli Ganga takes a northern course at Malari. Between Malari and Tapoban it is almost a narrow gorge with perpendicular cliffs on either side.The Dhauli Ganga is fed by Girthi Ganga at Kurkuti and Rishi Ganga 500 m. below Reni. It 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 DHT1, to DHT3. The DHT_1 is being the youngest and DHT3 is oldest terrace. The total average thickness of these terraces is 22 m and relative average thickness of these terraces is 10, 8 and 6 m respectively ((Khan, 1974, 1975 2022, 2023).

2.11.0 The Fluvial terraces of Bal Ganga Valley

The Bal-Ganga is a small tributary of Bhilagna. It rises from the ice clad peak (10746) 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 BLT1, to BLT3, the BLT1, it is being the lowest and youngest terrace, whereas BLT3, the oldest terrace. The relative average thickness of these terraces is 5, 10 and 7 m respectively. ((Khan, 1974, 1975, 2023).

2.12.0 The Fluvial terraces of Madhmeshwar Ganga Valley

The Madhmeshwar Ganga is a tributary of the Mandakini. The stream originates from glacier southwest of Kedarnath and joins Mandakini near Okhimut. It is controlled by NNE-SSW trending lineament. 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, from younger to older terraces respectively. The relative thickness of these terraces is 8 and 10 m respectively (Khan 1981).

These terraces constitute the complete sequence of sediments of fluvial domain measuring about 12 m deposited in Madhmeshwar Ganga valley during Quaternary period. ((Khan, 1974, 1975 2022, 2023).

2.13.0 Berhi Ganga Valley.

The Behri Ganga is a tributary of Alaknanda, it originates from glaciated top in the Central Himalaya in upstream of south east of Tapoban and joins Alaknanda between Joshimath and Chamoli it is known as the Alaknanda. The river has conspicuous straight ENE-course and descends down through the tight gorges with the steeply rising valley flanks. The river has formed one prominent fluvial terrace besides several channel and land form elements. These terraces are genetically both erosional and depositional in nature and have been designated as BRT1 is being the youngest is oldest terrace. The average thickness of these terraces is 5 m and relative average height is 8fromriver bed. ((Khan, 1974, 1975 2022, 2023)

3.1.0 The Statistical Computations

The statistical analysis of sediment sample of the Alaknanda valley and particle size distribution curves were expressed on a Φ scale. Folk and Ward's (1957) graphical method was adopted to calculate mean size (Mz), sorting (σI), Skewness (SKI) and Kurtosis (KG). This method involves the measurement of several percentiles from cumulative curves (Φ5, Φ16, Φ25, Φ50, Φ75, Φ84 and Φ95). The formulae are as follows:

$$\Phi = -\log_2 G$$

where G = the grain size (mm)
(i.e. sieve mesh opening)

Mean size

$$M_z = \frac{\Phi 16 + \Phi 50 + \Phi 84}{3}$$

Sorting

$$\sigma_I = \frac{\Phi 84 - \Phi 16}{4} + \frac{\Phi 95 - \Phi 5}{6.6}$$

Skewness

$$SK_I = \frac{\Phi 16 + \Phi 84 - 2\,\Phi 50}{2(\Phi 84 - \Phi 16)} + \frac{\Phi 5 + \Phi 95 - 2\,\Phi 50}{2(\Phi 95 - \Phi 5)}$$

Kurtosis

$$K_G = \frac{\Phi 95 - \Phi 5}{2.44(\Phi 75 - \Phi 25)}$$

The computed textural parameters of sediments and their binary relation applied as tool in differentiating the various environments of Quaternary sedimentation in Moila R.J. et.al. (1968) the same key is used as tool to analyze and differentiate sediments of various domains in Narmada valley.

3.2.0 Statistical Parameters of Glacial, Fluvio-glacial and Fluvial terraces of Alaknanda valley :

In Alaknanda valley 150 sand samples were collected, 50 each from glacial, fluvio-glacial and fluvial terraces from the starch of 225 km between Badrinath and Deoprayag.The results & findings and are discussed below (Plate No_1,2,3 & 4).

3.2.1 Glacial Terraces:

Mean Size (MZ)

The average mean size of Glacial terraces is 0.09 Ø (Coarse sand). It varies from -2.81 Ø to 2.8 Ø i.e. the sediment consist of very coarse sand to fine sand. The maximum value of (MZ) is -2.81 Ø near the origin of the river and minimum 2.8 Ø near the outer limit of these terraces around Chamoli. The (MZ) shows sharp decrease in size in first 25 km between Badrinath and Vishnurayag, corresponding to the steep slope of river. Down the stream Vishnuprayag although it show decrease in its value but display strong variation in size, which is attributed to the mixing of sediments brought by the sub-glacier joining the main Alaknanda at various points. It is seen that between Badrinath and Vishnuprayag the (MZ) constantly decreases; whereas downstream, the (MZ) between Joshimuth and Chinka show sharp fall,whereas close to the Chamoli, it again increases. The variation in the (MZ) in glacial terrace indicates the extensive mixing of sediment brought by sub-glacier meeting Alaknanda at different points.

Inclusive Graphic Standard Deviation (δ)

It is a measure of sorting which reflects the consistency in the energy level of depositing medium. In respect of glacial terraces the average standard deviation is 3.34 Ø (very poorly sorted). It varies from 2.00 Ø from 2.00 Ø to 4.30 Ø i.e. the sediments are poorly sorted to extremely poorly sorted. The relative variation and average distribution indicate that 20% of samples are poorly sorted, 58% very poorly sorted and 22% are extremely poorly sorted. The sediments however, show slight improvement in sorting downstream with fluctuation. The sediments of glacial terraces in the vicinity of confluence of major stream with Alaknanda show highly variable sorting with insignificant improvement. As a whole the sediments of these terraces are extremely assorted and are heterogonous in nature and multi source of their derivation.

Inclusive Graphic Skewness (SKI)

It denotes the symmetry of grain size frequency distribution. The symmetry curves posses zero value, these with excess fine material show positive value with these excessive coarse material have negative value. The average (SKI) for glacial sediments is 0.064 Ø i.e. the sediments are negative skewed. It ranges from -0.450 Ø to + 0.52 Ø i.e. the sediment are negative skewed to positive skewed, which indicate the tendency of gradual decrease in value of (SKI) in upstream direction as result of retreat of glacier and decrease in the transport capacity. The 56% of the sample shows the negative value and 44% positive value. Around Vishnuprayag, Chinka the sediments are very positive skewed to very negative skewed which seems to be due to mixing of sediments brought by various glaciers. The sediments down the stream of Badrinath have the strong tendency to be positive skewed.

Graphic Kurtosis (KG)

It indicates the peakedness of curve lower value of (KG) that sediment are (Platykurtic) points towards broad peak, while value of (KG) (Leptokurtic) denotes pronounced peak in the centre. The value of (KG) in the sediments of glacier terraces is highly variable. The average value is 0.716 Ø (platykurtic); whereas it varies from 0.49 Ø to 1.10 Ø (very platykurtic to leptokurtic).

The average value suggests the fluctuation in the energy condition of the glacier and most intense asorting in the sediments prevailed during the deposition. In Alaknanda valley along the stretch of 110 km between Chamoli and Badrinath there is general uniformity in (KG) value except in the confluence area where sudden variation are common.

Inspite of strong variation in (KG) in the vicinity around Chinka Vishnuprayag there is tendency in decrease in (KG) value towards upstream.

3.2.2: Fluvio-glacial terraces:

MEAN SIZE (MZ)

The average mean size of fluvio-glacial sediments is (medium sand). It varies from -2.53 Ø to 3.12 Ø i.e. the sediments consist of very coarse to very fine sand. The size distribution of these deposits in the study area is extremely irregular and erratic. Out of 50 samples 10% of sample show range of (MZ) of order of 0.75 Ø - 0.50 Ø , 21% 0.25 to 0.75 Ø , 25% 0.75 to 1.75%, 35% 1.75 Ø to 2.50 Ø and 19% beyond 2.50 Ø . The sediments near the outer edge of glacial deposit downstream of Chamoli ranges 0.75 Ø to 0.50 Ø i.e. coarse to very coarse sand which constantly show decrease in (MZ) along the stretch of 30 km upto Karanprayag. The sediments between Chamoli and Karanprayag along a stratch of 45 km show range of order of 1.25 Ø to 2.75 Ø with local variation. The sudden rise in (MZ) is noticed around Nandaprayag and downstream and downstream of confluence of Alaknanda and Nandakini (MZ) values are of order of 0.50 Ø to 0.15 Ø, which indicates the intensive mixing of sediments brought from the flash stream resulting from the retreating glacier at different point in the valley. The decrease in size downstream up to Karanprayag along a distance of about 30 km is without any anomaly. The variation in (MZ) down the confluence of Alaknanda and Pindar is very conspicuous, which is assumed to be the adding of a large bulk of sediments perhaps brought by sub-glacier along the Pindar valley, from the close proximity of provenances.

Inclusive Graphic Standard Deviation (δ)

The standard deviation of fluvio-glacial sediments varies from 0.95 to 2.50 Ø i.e. the sediments are poorly sorted to very poorly sorted. The average standard deviation is 1.563 Ø (extremely poorly sorted). Out of 50 samples 8% are moderately sorted, 10% poorly sorted and 32% are very poorly sorted. The sediments near the source area conspicuously exhibit poor sorting and show significant improvement down the stream with local variation. As a whole the sediments are poorly sorted to very poorly sorted and heterogeneous in nature.

Inclusive Graphic Skewness (SKI)

The fluvio glacial sediments show skewness ranging from -0.48 Ø to - 0.97 Ø i.e. the sediments are skewed very negative to skewed very positive. The average of (SKI) is 0.078 Ø i.e., the sediments are fine skewed. Out of the total samples of these terraces 56% are skewed positively, 16, skewed positive and 22, are skewed very negative. The assemblage of variable value of (SKI) suggests the heterogeneous association of the sediments ranging from fine sand to gravel size. The (SKI) value in general increase downstream with occasional variation. It is perhaps due to repeated reworking of the sediments towards downstream side by flash stream resulting from the glacier. The 75% of the sample show skewness between the ranges -0.40 Ø to 0.30 Ø which indicates conspicuous hetrogenous assemblage of sediments in terraces of fluvio-glacial domain of Alaknanda.

Graphic Kurtosis (KG)

The average (KG) is 1.316 (leptokurtic). It ranges from 0.76 Ø to 1.52 Ø (platykurtic to very leptokurtic) among these 75% of the sample fall in very platykurtic class 47.50 (mesokurtic) and 45, (leptokurtic). The assemblage of these different classes of kurtosis suggests the dominance of coarse sediments (Folk & Ward, 1957). Most of the samples between Chamoli and Karanprayag section along the starch of about 45 km show the Kurtosis value ranging between 0.90- 1.20 Ø except in the area around Nandaprayag Nagrasu, where the sedimentation is perhaps affected by lateral mixing of sediments brought by the sub-glaciers. It seems that sediments were transported and deposited in the oscillating kinetic condition.

3.2.3: Fluvial Terraces:

MAN SIZE (MZ)

The average mean size for the sediments of fluvial terraces of Alaknanda is 2.458 Ø. The maximum value of (MZ) is -0.491 Ø is noticed near Karanprayag while minimum 4.545 Ø at Deoprayag, near the confluence of Alaknannda and Bhagirathi River. The (MZ) shows the significant consistency in its value in the first stretch of about 35 km between the Karanprayag and Nagrasu, corresponding to the flattered and gentle slope of the river bed. Down the stream of Nagrasu for about 75 km upto Deoprayag (MZ) sharply decreases perhaps due to sharp change in bed slope of Alaknanda. In this section (MZ) strongly fluctuates around Kaliyasour, Srinagar and Kirtinagar for about 25 km which correlated to the sudden convexity in the river bed due to e Neotectonic activity in the vicinity of Srinagar fault/ North Almora thrust, which traverses across the Alaknanda around Kaliyasour.

It seems that the mean size of fluvial sediments sharply follow the bed slope, pointing to exponential longitudinal profile, thus decrease in (MZ) in the downstream of the Alaknanda is result of decrease in both transporting capacity and velocity of the river towards the later phases of sedimentation in the valley.

Inclusive Graphic Standard Deviation (δ)

The average standard deviation is 0.691 Ø (moderately sorted) and it ranges from 0.15 Ø to 1.52 Ø i.e. the sediments are very well sorted to poorly sorted. In the upper Alaknanda it shows consistency in value along the greater length, except around, Karanprayag and Rudraprayag, where Nandakini Pindar and Mandakini joined Alaknanda respectively. The variation in and around these places appears to be due to mixing of sediments brought by these tributaries. The sharp improvement in sorting is noticed downstream of Rudraprayag upto Srinagar which seems to be related with the repeated reworking of sediments and slope element. The sudden decline in sorting coefficient in the stretch of about 15 km between Srinagar and Kirtinagar appears to be due to either the non-transport of larger grain down current or due to loss of bed slope of Alaknanda in this Segment of valley. The significant increase in sorting in down current of Kirtinagar indicates cyclic reworking of sediments appears due to re-activation of channel in this part of valley.

Inclusive Graphic Krewness (SKI)

The average (SKI) of fluvial sediments is 0.00281. It ranges from -0.99 Ø to 0.99 Ø i.e. the sediments are coarse to fine skewed. The (SKI) exhibits tendency of gradual increase in value downstream with local variation. This suggests relative increase of fine grains, down the stream. The sediment upstream of Karanprayag is negative skewed perhaps due to mixing of sediments of fluvio glacial origin.

Inclusive Graphic Kurtosis (KG)

The kurtosis of fluvial sediments of Alaknanda is highly variable, it ranges from 0.72 Ø to 1.72 Ø (leptokurtic) and an average value 1.264 Ø (platykurtic to very (leptokurtic). The average values suggest the fluctuation in the energy condition of the channel system. The mean value of kurtosis revealed the more intensive sorting of central part of size distribution curve than the tails. Along the course of Alaknanda in Nadaprayag and Deoprayag section for a distance of about 75 km except local variation around Karanprayag, Rudraprayag, there is strong tendency in increase of kurtosis value downstream.

4.1.0 Statistical Parameters of Glacial, Fluvio-glacial and Fluvial terraces of Bhagirathi valley :

In Bhagirathi valley 150 sand samples were collected, 50 each from glacial, fluvio-glacial and fluvial terraces from from the starch of 175 km between Gangotri and Deoprayag. (Plate No_ 1, 2 4).

The results are discussed here under.

4.2.0 GLACIAL TERRACES:

Mean Size (MZ)

The average mean size of glacial terraces is 2.55 Ø (Fine sand). It ranges from -0.87 Ø to 3.42 Ø i.e. the sediments consist of coarse to fine sand with silt and clay. The (MZ) in the area around Gaumukh and Gagnani section in the upper Bhagirathi significantly decreases downstream, except with very little variation around Sukhi, where as a sudden rise in (MZ) is conspicuous features around Malla . The behavior of mean size in this segment represents the steeper slope of Bhagirathi and anomaly in (MZ) around Sukhi assumed to the lateral mixing of sediments brought by sub-glacier from close proximity. In Gagnani and Bhatwari section along the length of 45 km the (MZ) shows consistency with no significant variation.

Inclusive Graphic standard deviation (δ)

The average standard deviation is 2.35 Ø (very poorly sorted). It varies from 1,420 Ø to 3.885 Ø i.e. the sediments are poorly sorted to extremely poorly sorted. The majority of the sample shows the range of standard deviation of order ranging from 2.00 Ø to 3.255 Ø. The 60% of sample show poor sorting, 25% very poor sorting and 35% extremely poor sorting. The sediments show significant improvement in sorting downstream of Gaumukh in upper Bhagirathi, with anomalous variation around Sukhi, Gagnani and Uttarkashi. The variation in sorting appears to have been related with mean size, which is greatly affected by lateral mixing of sediments brought by sub-glacier joining main valley at various points.

Inclusive Graphic Skewness (SKI)

The average skewness is 0.258 Ø (very negative skewed). It ranges from -0.425 Ø to + 0.215 Ø, which ascribe that the sediments are very negative to positive skewed. The 15% samples are very negative skewed, 30% negative skewed, 15% nearly symmetrical and 15% positive skewed and 10% very positive skewed. The 54 samples along the length of 85 km in upper Bhagirathi valley are coarse skewed and 46% fine skewed. The sediments as a whole show strong departure towards coarseness as well as with fineness. The departure from symmetry appears to be related with deviation of mean size. In general the asymmetry passes from upstream to downstream as coarse skewed to fine skewed, which indicates constant decrease in energy condition of the system during sedimentation.

Graphic Kurtosis (KG)

The average value of kurtosis is 0.98 (Masokurtic). It ranges from 0.65 Ø to 1.84 % (very platykurtic to very leptokurtic). The 6% samples are very leptokurtic, 50% mesokurtic, 21% leptokurtic, 23% are platykurtic. The average value suggests fluctuation in the energy condition of the system. Inspite of variation (KG) increases downstream, which is perhaps related with sorting deviation.

4.3.0 Fluvio-glacial Terraces :

Mean Size (MZ)

The average mean size is 1.225 Ø. It ranges from -2.580 Ø to 2.255 Ø i.e. the sediments consist of very coarse sand to fine silt and clay. The maximum value - 2.580 Ø is noticed around Bhatwari and the minimum 2.255 Ø at Nakuri. The (MZ) shows significant decrease in size from Gagnani to Uttarkashi for the distance of about 35 km which corresponds to the steep slope of river bed of Bhagirathi. The downstream of Uttarkashi show further significant decline in the size but with strong fluctuation, which appears to be due to strong making of sediments brought by the streams resulted consequent upon the meeting of glacier at various points along the length of valley.

Inclusive Graphic Standard Deviation (δ)

The average standard deviation is 1.752 Ø (poorly sorted). It ranges from 1.002 Ø to 3.421 Ø. The 54% of samples are poorly sorted and rest 44% very poorly sorted. The 94% of the samples show the sorting beyond 1.302 Ø i.e. the majority of sediments are poorly sorted to very poorly sorted. The sediments show strong fluctuation in the sorting but decline to exhibit any significant improvement downstream.

Inclusive Graphic Skewness (SKI)

The average skewness value is -0.215 Ø (very negative skewed). The skewness of fluvio-glacial sediments varies from -0.415 Ø to 0.325 Ø i.e. sediments are strongly coarse to fine skewed. The 24% of the samples are negative to very negative, skewed, 30% negative skewed, 30% nearly symmetrical, 15% positive skewed and 1% is very positive skewed. The skewness value of these sediments indicates the diverse and heterogeneous association of the sediments ranging in size from fine sand to gravel. The (SKI) shows sharp increase in its value downstream with local variation.

Graphic Kurtosis (KG)

The average kurtosis is 1.221 Ø (very leptokurtic). It varies from 0.872 Ø to 2.112 Ø. The 3 samples are platykurtic, 18% mesokurtic, 24% are leptokurtic, and 55% are very leptokurtic. The sediments were poorly sorted in the central part of size distribution curve than the tails. In the stretch of 45 km despite the local variation the (KG) does not show steady decrease in its value downstream. The local variation seems to be due to local mixing of sediments brought by the net flash streams resulted due to melting of glacier at different places and joining the main stream Bhagirathi at various points in the valley.

4.4.0 Fluvial Terraces:

Mean Size (MZ)

The average mean size is 1.499 Ø (very coarse sand). It varies from 1.252 Ø to 2.58 Ø i.e. the sediments consist of very coarse to very fine sand, silt and clay. The (MZ) inspite of variation sharply decreases downstream. In Nakuri and Tehri section for the distance of about 60 km, there is not much variation of (MZ) but downstream of Tehri upto Deoprayag, there is constant decrease in the (MZ), it is correlated with the former, appears to be due to gentle to flattened slope of river bed, where as the later to the steep fall in the gradient of the Bhagirathi in the Tehri Deoprayag section. The local variation around Nakuri, Dharasu, Tehri indicates the mixing of the sediments brought by subsequent streams towards the later phase of sedimentation.

Inclusive Graphic Standard Deviation (δ)

The average standard deviation is 0.462 Ø (moderately sorted). It varies from 0.220 Ø to 1.3340 Ø i.e. the sediments are moderately sorted to well sorted. The sorting of the sediments all along the section between Uttarkashi to Deoprayag to the distance of about 125 km show mark improvement downstream, but the strong local fluctuations around Dharasu, Uttasu and Tehri are very conspicuous. It seems to be due to lateral mixing of sediments brought by tributaries viz. Jalkhur, Bhilangna joining Bhagirathi at different points. In the upper Bhagirathi in Uttarkashi Tehri section, sorting improves with distance; whereas in the lower Bhagirathi in Tehri and Deoprayag section it becomes poorer. The down current improvement of sorting in the upper Bhagirathi is probably related to decrease in size due to non transport of the larger grains downstream. Decrease in the sorting of the lower Bhagirathi is related to the increase in the fine grain sediments.

Inclusive Graphic Skewness (SKI)

The average skewness is + 0.265 Ø (positive skewed). It varies from -0.423 Ø to + 0.632 Ø 1.e. the sediments are negative skewed to very positive skewed. The 70% samples are negative to very negative skewed, 60% are near symmetrical, 12% is positive skewed and 14% are very positive skewed. The skewness shows sharp fall in its value downstream. It suggests the in downstream increase at fine fraction in the sediment load due to low carrying capacity of channel system. In the upper Bhagirathi the samples show the negative value and the sediments show strong departure from symmetry towards coarseness and fines around Dharasu, Seansu and Tehri. In Tehri, Deoprayag section the sediments are sharply positively skewed.

Graphic Kurtosis (KG)

The average value of kurtosis is 1.212 Ø (leptokurtic). It varies from 0.752 Ø to 1.423 Ø i.e. the sediments are platykurtic to leptokurtic in nature. The 30% of the samples are platykurtic; 52% are mesokurtic and 18% are leptokurtic. The average value 1.212 Ø suggest frequential change in the energy condition of channel system of Bhagirathi and more active and intense sorting of central part of size distribution curve than the tail. Along the entire length of about 180 km of Bhagirathi, from its source at Gaumukh to Deoprayag, where it joins Ganga, except local variation there is strong tendency of decrease in (KG) downstream.

5.0.0 Statistical Parameters of Fluvial terraces of Bhilangna valley :

In Bhilangna valley 50 sand samples were collected from the different terraces of fluvial regime in Bhilangna valley from a stretch of 70 km between Ghansali and Tehri.(Plate No.1, 2_ & 3& 5)

The results are are dicussed below.

Mean Size (MZ)

The average mean size of the sediments fluvial terraces of Bhilangna is 1.752 Ø, whereas it ranges from 0.525 Ø to 3.22 Ø i.e. the sediments consist of coarse to fine sand. The maximum value of (MZ) is 6.525 Ø near Ghanshali, while minimum is 3.22 Ø near the confluence with Bhagirathi at Tehri. Inspite of local variation (MZ) it decreases downstream, which corresponds to the steep slope of Bhilangna. The variation in (MZ) indicates the mixing of sediments brought by subsequent stream joining Bhagirathi at various point.

Nevertheless, the (MZ) of fluvial terraces of Bhilangna broadly follows the bed slope pointing to exponential longitudinal profile. The decrease in (MZ) size indicates both decrease in transporting capacity and velocity of the channel system.

Inclusive Graphic Standard Deviation (δ)

The average standard deviation (δ) of sediments is 1.552 Ø. It ranges from 0.581 Ø to 2.121 Ø i.e. the sediments are poorly sorted to well sorted. Except with little local variation, the sorting of sediments increases downstream. The variation suggests the mixing of local sediments brought by contributories streams from close proximity. The 75% of the samples are represented by the range of sorting of order of 1.225 Ø to 1.852 Ø, the 20% 1.852 Ø to 2.122 Ø and 5% 0.580 Ø to 1.852 Ø.down thestream respectively.

Inclusive Graphic Skewness (SKI)

The average skewness is +0.355 Ø. It varies from -0.525 Ø to +0.555 Ø i.e. the sediments are negative to positive skewed. The 35% samples are nearly symmetrical, 45% are positive skewed. 12% very positive skewed 3% negative skewed and 3% very negative skewed. The skewness value sharply increased downstream, which suggest the constant increase of fines fraction of sediments and low load capacity of the channel system.

Inclusive Graphic Kurtosis (KG)

The average value of kurtosis is 1.285 Ø. It ranges from 0.552 Ø to 1.560 Ø i.e. the sediments are very platykurtic to leptokurtic. The average value of (KG) indicates fluctuation in the energy of the channel. The 66% samples are leptokurtic, 12% are mesokurtic 12% are platykurtic, 10% are very platykurtic. Inspite of strong fluctuation the (KG) shows steady increase in its value downstream.

6.0.0 Statistical parameters of Fluvial terraces of Nandakini valley:

In Nandakini valley 50 sediment samples collected for statistical analysis from from the different terraces of fluvial regime from the stretch of 70 km between Ghat and Nandaprayag for sedimentological study. (Plate No.1, 2_ & 3& 6)

Mean Size (MZ)

The average mean size of the sediments of fluvial terraces of Nandakini is 1.765 Ø, whereas it ranges from -0.330 Ø to 3.255 Ø i.e. the sediments consist of very coarse sand to very fine sand. The maximum size of sediment -0.330 Ø is noticed around Ghat, whereas the minimum size 3.255 Ø is around Nanda- prayag. The (MZ) except little variation it display steady decreases downstream, which suggest repeated reworking of sediments from the source and also decline in the steady load carrying capacity of the channel system towards downstream.

Inclusive Graphic Standard Deviation (δ)

The average standard deviation (δ) is 1.655 Ø of sediment it varies from 0.625 Ø to 2.850 Ø i.e. the sediment are moderately sorted to poorly sorted. The sediments show improvement in sorting downstream. The 20% samples are moderately sorted 35% are poorly sorted and 45% are very poorly sorted. The 80% of samples in the upper Nandakini are poorly sorted to very poorly sorted, which show sharp improvement downstream. The poor sorting in the upper Nandakini valley is due to close proximity of sediments source and improvement in sorting-downstream by repeated reworking of sediments and steady increase of finer fractions.

Inclusive Graphic Skewness (SKI)

The average value of skewness is +0.285 Ø it varies from -0.525 Ø to + 0.550 Ø i.e. the sediments are negative skewed to very positive skewed. The 42% samples are negative skewed, 30% samples are nearly symmetrical 18% are positive skewed and 10% samples are very positive skewed. The (SKI) value increases downstream indicates calm and stable energy condition towards late history of sedimentation in valley .

Graphic Kurtosis (KG)

The average value of kurtosis is 0.745 Ø (platykurtic) and it varies from 0.525 Ø to 1.385 Ø i.e. the sediments are very platykurtic to leptokurtic. Out of the samples 10% are very platykurtic 18% samples are platykurtic 26% samples mesokurtic, 20% are leptokurtic and 26% are very leptokurtic, except local variation (KG) has got strong tendency to decrease downstream

7.0.0. Statistical Parameters of Fluvial terraces Mandarinivalley: .(Plate No.1, 2_ & 3& 7)

In Mandakini valley 70 sand samples were collected from the different terraces of fluvial regime from a stretch of 70 km between Gupkashi and Rudraprayag (Plate No.1, 2_ & 3& 7)

The results are discussed below

Mean Size (MZ)

The average mean size is 2.688 Ø. It varies from 0.821 Ø to 4.225 Ø i.e. the sediments consist of very coarse to very fine sand. The (MZ) except a little variation it progressively decreases downstream. In the upper stretch between Guptkashi and Kund-Chatti, it shows steady value, whereas downstream it constantly decreases upto Rudraprayag. The sharp fall in (MZ) is noticed between Agastmuni, and Rudraprayag which appears to be related with steep gradient of the Mandakini River.

Inclusive Graphic Standard Deviation (δ)

The average standard deviation is 0.985 Ø (moderately sorted). It varies from 0.452 Ø to 1.955 Ø (poorly sorted to well sorted. The standard deviation of sediment except some local variation, show steady improvement downstream. The fluctuation in sorting around Kund-Chatti and Agastmuni are of very strong nature, these appear to have been related with the mixing of sediments, brought by net work of streams, joining Mandakini in this segment of valley. In the upper Mandakini, sorting significantly increases with the distance, whereas in the middle segment of Mandakini it strongly fluctuates and in the lower part of valley downstream of Agastmuni, it shows sharp improvement. The overall improvement down the current is related to the increase in fine grained fraction of sediments and repeated reworking of sediments.

Inclusive Graphite Skewness (SKI)

The average value of skewness is 0.438 Ø. This varies from 200 Ø to +0.82 Ø i.e. the sediments are negative skewed to very positive skewed. The 55% of samples show, skewness ranging etween -0.10 Ø to 0, 10 Ø, the 6% beyond +0,410 Ø, 35% 0.10 Ø to +0.40 Ø and 5% between -0.20 Ø to 0.30 Ø. The strongly skewed positive to strong skewed negative tendency of sediments from upper to lower Mandakini revealed constant increase in finer sediments downstream. The little variation in skewness around Agastmuni and Rampur, appears to be due to local mixing of sediments brought by small stream from close proximity.

Graphite Kurtosis (KG)

The average value of kurtosis is 1,135 Ø (leptokurtie). It ranges from 0,60 Ø to 1.345 Ø. It ranges from The 10% samples are (platykurtie), 30% (platykurtio, to mesokurtie), 37% are leptokurtie, and 23% are very leptokurtic. The kurtosis value, except local variation around Kund-Chatti , and Rampur constantly decreases downstream along the length of 70 km from Guptkashi to Rudraprayag. (Khan 1985).

8.0.0 Statistical Parameters of Fluvial terraces of Pindar valley:

In Pindar valley 30 sand samples were collected from the different terraces of fluvial regime from a stretch of 65 km between Thanala Karanpryag for sedimentological study. .(Plate No.1, 2_ & 3& 9)

The results are are dicussed below

Mean Size (MZ)

The average mean size of sediments of fluvial terraces is 1.552 Ø. It ranges from -0.752 Ø to 3.255 Ø i.e. the sediments consist of coarse to very fine sand. Except local variation (MZ) it decrease downstream. The variation of (MZ) in the valley appears to have been related with the local addition of the sediments to the main sediment regime of the channel by small tributaries. The 27% of the samples show the (MZ) of order ranging between 0.752 Ø to 1.255 Ø, whereas the 63% between 1,255 Ø, to 3.552 Ø. The sediment samples in the lower Pindar valley show average value of (MZ) around 1.550 Ø, which indicate repeated reworking of sediments downstream in considerably stabilized energy condition of the channel perhaps due to less variation in the channel gradient.

Inclusive Graphic Standard Deviation (δ)

The average standard deviation is 1.855 Ø. It varies from 0.625 Ø to 2.820 Ø i.e. the sediments are poorly sorted to well sorted. The sorting of sediments in general except local variation increases downstream. The 30% samples are very poor sorted, 25% moderately sorted and 45% are well sorted. As a whole the sediments show improvement downstream in valley.

Inclusive Graphic Skewness (SKI)

The average skewness is +0.258 Ø. It varies from -0.352 Ø to 0.425 Ø i.e. the sediments are negative skewed to very positive skewed. The 40% samples are negative skewed, 30% nearly symmetrical and 18% positive skewed and 12% are very positive skewed. The skewness values except local variation increases downstream. The strong tendency of the sediment from very negative skewed to very positive skewed indicate the steady increase of finer sediments towards down current in the valley.

Inclusive Graphic Kurtosis (KG)

The average kurtosis value is 1.165 Ø. It varies from 0.752 Ø to 1.255 Ø i.e. the sediments are platykurtic to very leptokurtic. The 30% samples are platykurtic, 50% are mesokurtic, 20% are leptokurtie and very leptokurtic. Inspite of local variation in value of (KG) there is a strong tendency for decrease in its value downstream.

9.0.0 Statistical Parameters of the sediment of Fluvial terraces of Dhauli -Ganga valley:

In Dhauli Ganga valley 19 sediment samples were collected from the different terraces of fluvial regime from a stretch of 65 km between between Niti pass and Joshimuth5 for sedimentological study. (Plate No.1, 2_ & 3). The results are discussed below

Mean size (1)

The average mean size for sediments of fluvial terraces of Dhauli-Ganga is 2.251 Ø (fine sand). It varies from 1.370 Ø to 3.158 Ø i.e. the sediments consist of pre-dominantly medium to fine sand. The mean size in general decrease down the stream, except local variation, in the middle part of valley between Malari and Lata and thereafter the mean size decrease downstream. The downstream of lata upto Joshimuth the sediment exhibit steep fall in mean size, which is seems appears to be related with the steep slope of valley. The mean size show inverse relation with standard deviation all along the length of 110 km in the Dhauli-Ganga between Niti pass and Joshimuth as the mean size decreases down the current sediment show improvement in sorting.

Inclusive Graphic Standard Deviation (δ)

The average standard deviation for the sediments of fluvial terraces of Dhauli-Ganga is 0.269 Ø (moderately sorted) and it varies from 0.55 Ø to 4.92 Ø 1.e. the sediments are extremely poorly sorted to moderately sorted. In the upper part of Dhauli-Ganga between Niti pass and Malari the sediments show little variation and majority of samples display extremely poor sorting. Although sediments show little variation in valves, but exhibit significant improvement in sorting down the current. In Lata and Joshimuth in the lower part of the valley, the sediments show fluctuation, which appears to be related with decrease in (MZ) and increase in coarser fraction of sediment in the valley. In general sorting of sediment except local variation show improvement down the stream.

Inclusive Graphic skewness (SKI)

The average value of skewness is -0.425 Ø (very positive skewed). It varies from +0.541 Ø to -0.562 Ø i.e. the sediment are negative skewed to very positive skewed. In the upper reaches in Niti pass and Malari section the sediments are strongly negative skewed 1.e. the sediment predominently consist of coarse sediments. In the middle part of valley in Malari and Lata section the it shows strong variation i.e. the sediments are both strongly negative skewed and positive skewed. In lata and Joshimuth section the sediment display steep rise in the skewness values i.e. the sediment become, strongly positive skewed. In the upper reaches strongly negative skewed nature of sediment reveal the close proximity of provenance. The variation in skewness in Malari and Lata section indicates strong lateral mixing of sediments by subsequent streams. In Lata and Joshimuth the strongly positive skewed nature of sediments reveal relatively increase in fine grained fraction in the down the stream which is correlated with decline in transporting capacitydue to low energy condition of sedimentation.

Graphic Kurtosis KG)

The average value of kurtosis is 0.825 Ø (platykurtie). It varies from 0.432 Ø to 1.312 Ø very platykurtic to leptokurtic. In upper reaches between Niti pass and Malari, except local variation the value of kurtosis in general decreases. In Malari and Lata section it show strong fluctuation, whereas in Lata and Joshimuth section local variation of kurtosis sharply decrease 1.e. the sediments have strong tendency to become from leptokurtic to very platykurtic down the stream.

10.0.0 Statistical Parameters of the sediments of Fluvial terraces of Bal-Ganga valley:

In Bal Ganga valley 16 sediment samples collected from fluvial terraces for statistical analysis from the stretch of 40 km between between Danwali and Ghansyali . .(Plate No.1, 2_ & 3& 8)

The results are discussed below

Mean Size (MZ)

The average mean size for sediments of fluvial terraces of Bal-Ganga is 2.392 Ø (fine sand). It varies from -2.98 Ø to 3.10 Ø i.e. the sediment mainly comprises of very small pebbles to very fine sand. The (MZ) in upper reaches upstream of Thathikathur, except little variation in the middle part of valley it progressively decrease down the stream. In between Thathikathur and Chamyala it shows strong variation, whereas down the stream of Chamyala a significant steep fall in mean size is noticed. The variation in the Thathikathur and Chamyala seem to be related with lateral mixing of sediments. The conspicuous decrease in (MZ) down the stream of Chamyala appears to have related both with the steep change in the valley gradient and repeated reworking of sediments in the valley. The (MZ) has inverse relation with sorting in the valley, as the mean size decreases down the stream the sediments show significant in sorting.

Inclusive Graphic Standard Deviation (δ)

The average standard deviation for sediment of terraces of fluvial domain is 0.388 Ø (well sorted), where as it varies from 0.327 Ø to 0.51 Ø i.e. the sediment of fluvial terraces are moderately sorted to very well sorted. In upper reaches upstream of Thathikathur except little variation the sorting values decrease down the stream which indicates improvement in sorting. In the Thathikathur and Chamyala section it show strong fluctuation which is perhaps due to lateral mixing of sediments, whereas down the stream of Chamyala the sediment show distinct and sharp improvement in sorting which is inversely related with the (MZ). The steep fall in the valley gradient down the stream of Thathikathur also has important bearing on these two parameters in the valley.

Inclusive Graphic Skewness (SKI)

The average value of skewness is +0.385 Ø that the sediment are very positive skewed. It varies from -0.553 Ø to + 0.551 Ø i.e. the sediments are negative skewed to positive skewed. In the upper stream of Thathikathur the sediment generally show little variation in skewness value and are negative skewed. In between the Thathikathur and Chamyala skewness show strong variation in values 1.e. sediments are nearly symmetrical and are both negative and positive skewed, whereas down the stream of Chamyala, there is steep increase in values of skewness and the sediment have got very strong tendency to become positive skewed. In general the skewness values increases down the current indicating progressive increase of finer sediments in the lower part of valley, it seems to be due to with repeated reworking and rapid transport of sediments from the source area during sedimentation.

Graphic Kurtosis (KG)

The average value of kurtosis is 0.898 Ø (Platykurtic). It varies from 0.525 Ø to 1.521 Ø i.e. sediments are leptokurtic to very platykurtic in nature. In upstream of Thathikathur, except little variation the overall value of kurtosis decreases down the stream i.e. the sediments become from leptokurtic to mesokurtic in nature. Thathikathur and Chamyala section inspite of fluctuation the value of kurtosis increases i.e. sediments show tendency to become leptokurtic, whereas down the stream of Chamyala the values of kurtosis sharply decreases and the sediment show strong tendency to become platykurtic in nature. In general the kurtosis except local variation between Thathikathur and Chamyala section it displays steady decrease in values i.e. the sediments show the tendency to become from leptokurtic to platykurtic in nature down the current in the valley.

11.0.0 Statistical Parameters of the sediments of Fluvial Terraces of Madhmeshwar Ganga valley:

In Madhmeshwar Ganga valley 16 sediment samples were collected from fluvial terraces for statistical analysis from the stretch of 45 km between Bantoli and Okhimuth. (Plate No.1, 2_ & 3&10)

The results are discussed below:

Mean size (MZ)

The average mean size for sediments of fluvial terraces of Madhmeshwar Ganga is 1.199 Ø (medium sand). It varies from 1.522 Ø to 1.989 Ø 1.e. the sediments pre-dominantly medium to very coarse sand. In the upstream of Ransi the (MZ) constantly decreases down the stream, perhaps due to steeper slope of the valley. In between Ransi and Rawa it shows strong variation, whereas down the stream of Ransi a significant and progressive decrease in (MZ) is noticed. The variation, in (MZ) between Ransi and Rawa appear to related with the lateral mixing of sediments brought by net work of subsequent stream joining the central part of valley at various places, whereas the decrease of (MZ) downstream of Rawa is seem to be with due to steep bed slope in the lower valley.

Inclusive Graphic Standard Deviation (S

The average standard deviation of the sediments of fluvial terraces of Madhmeshwar Ganga is 1.359 (very poorly sorted). It varies from 0.521 Ø to 3.489 Ø i.e. the sediments are very poorly sorted to moderately sorted. In the upstream of Ransi the values of sorting decrease down the stream, which indicate improvement in sorting of sediments. In between Ransi and Rawa it shows strong fluctuation, which seem to be due to lateral mixing of sediments in central part of valley. The downstream of Ransi values of sorting progressively decreased depicting the sharp improvement in sorting of the sediment down the current of valley. This shows inverse relation of (δ) with (MZ) down the current 1.e. as the sorting of sediments increases (MZ) decreases.

Inclusive Graphic skewness (SKI)

The average value of skewness is + 0.496 Ø (very positive skewed). It varies from +0.22 Ø to + 0.725 Ø i.e. the sediments are positive skewed to very positive skewed. In the upstream between Rawa and Banloli the values of skewness show variation i.e. the sediments are both coarse skewed and fine skewed. The downstream of Rawa the sediment show constant increase in values of skewness which reveal the strong tendency of sediments to become fine skewed as the result decrease in load carrying capacity of channel system during sedimentation perhaps due to loss in bed slope in the lower part of valley.

Graphic kurtosis (KG)

The average value of kurtosis is 0.799 Ø (platykurtic). It varies from 0.320 Ø to 1.210 Ø i.e. the sediments are leptokurtic to very platykurtic in nature. In upstream of Ransa the values of kurtosis show strong fluctuation, whereas the down the stream of Ransa there is marked decrease in the value of kurtosis i.e. the sediments show strong tendency to become platykurtic in nature down the current in the Madhmeshwar Ganga valley.

12.0.0 Statistical Parameters of the sediments of Fluvial terraces of Berhi-Ganga valley:

In Dhauli Ganga valley 10 sediment samples were collected from fluvial terraces for statistical analysis from the stretch of 25 km. (Plate No.1, 2_ & 3)

The results are discussed below:

Mean size (MZ)

The average mean size for the sediments of fluvial terraces of Berhi Ganga is 0.2695 Ø (very course sand). It varies from -0.329 Ø to +0.325 Ø i.e. the sediments consist of very coarse sand to very fine sand. In the Berhi Ganga except local variation around Irni the (MZ) of sediment decrease down the current which appears to be related with the steep slope of valley.

Inclusive Graphic Standard Deviation (δ)

The average standard deviation of sediments of fluvial terraces in Berhi Ganga is 2.430 Ø (very poorly sorted). It varies from 0.521 Ø to 3.272 Ø i.e. sediments in general are poorly sorted to moderately sorted. Except little variation in sorting around Irni the sorting of sediments show progressive and sharp improvement down the current assumed to be due to repeated reworking of sediment and steep slope of valley segment

.Inclusive Graphic skewness (SK)

The average value of skewness is + 0.188 Ø (positive skewed). It varies from -0.285 Ø to 0.248 Ø i.e. the sediments are negative skewed to positive skewed. In the upstream of Irni the skewness of sediments show strong fluctuation indicating that the sediments are both strongly fine skewed and coarse skewed. Down the stream of Irni significant increase in skewness value reveal the tendency of sediments to become fine skewed indicating decrease in transporting capacity of channel down the current in the valley.

Graphic kurtosis (KG)

The average value of kurtosis is 1.256 Ø (very leptokartie). It varies from 0.546 Ø to 1.589 Ø (very leptokurtic to very platykurtic). The kurtosis value except variation upstream of Irni constantly decreases which indicate strong tendency of sediments to become platykurtic in nature down the current in the Berhi Ganga.

13.0.0 Statistical Parameters of the sediments of Fluvial terraces of Ganga River :

In Ganga valley 30 sediment samples collected from fluvial terraces for statistical analysis from the stretch of 85 km down the stream of Deoprayag to Reshikesh .(Plate No.1, 2_ & 3)

The results are discussed below:

Mean size (MZ)

The average mean size of sediments is 2,288 Ø (fine sand) it varies from 0.480 Ø to 3.720 Ø i.e. the sediments consist of coarse sand to fine silt and clay. The 55 samples show mean size between 2.50 Ø to 3.50 Ø, 21% between 1.00 to 2.00 Ø and 24% below 1.00 Ø and 14%. -2.98 Ø to 3.10 Ø i.e. the sediment mainly comprises of very small pebbles to very fine sand. The mean size except local variation constantly decreases down the stream.

Inclusive Graphic Standard Deviation (δ)

The averages standard deviation of sediment is 0.881 Ø (moderately sorted), whereas it varies from -0.310 Ø to 0.140 Ø i.e. the sediments are moderately sorted to very well sorted. The 55% of sample show sorting between 0.40 Ø to 1.20 Ø the 38% between 1.20 Ø to 1.80 Ø and 7% between 2.00 Ø to 2.32 Ø. The sediments show sharp improvement in sorting down the stream of Ganga valley.

Inclusive Graphic Skewness (SKI)

The average skewness value is -0.185 Ø (negative skewed). It varies from -0.312 Ø to 0.145 Ø i.e. the sediments are negative skewed to very positive skewed. The 20% samples show skewness between

0.040 Ø to 0.152 Ø, 35% - 0.045 Ø to 0.098 Ø and 45% samples between 0.450 Ø to 0.210 Ø except little variation the skewness value increase downstream.

Inclusive Graphic Kurtosis (KG)

The average kurtosis value is 1.716 Ø (very leptokurtic). It ranges from 0.550 to 1.990 Ø i.e. the sediments are very platykurtic to very leptokurtic. The 65% samples show kurtosis value of order between 0.860 Ø to 1.120 Ø, 25% between 1.262 Ø to 1.700 Ø and 10% between 0.620 Ø to 0.650 Ø except local variation the kurtosis value decrease downstream.

14.0.0 CONCLUSION

The sedimentological study in Alaknanda and its tributaries in upper Ganga basin has been attempted in parts of de Uttarkashi,Chamoli, Pauri and Tehri districts in parts of QA sheet 53J and 53 N on 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 Alaknanda,Bhagirathi,Bhilangna, Nandakini, Mandakini, Pindar, Dhauli- Ganga Bal- Ganga , Madhmeshwar Ganga and Berhi Ganga. The Alaknanda is chracterised by six terraces followed by Bhagirathi with five terraces, Bhilangna Nandakini four terraces Mandakini /Pindar/Dhauli-Ganga /Balganga three terraces, Madhmshwar Ganga two terraces and Berhi Ganga one terrace, amidst these Alaknanda is trunk stream and others are tributaries. The Alaknanda is trunk stream and other are tributaries.

The Alaknanda is the trunk stream of Ganga system, it drains the eastern part of the area of study .The rocks of Alaknanda valley and adjoining area consist of three units viz Central Cryastalline, Garhwal Group and Dudatoli Groups which from north to south are separated by thrust or fault. The Central Crystalline Group in this area consist of of northerly dipping sequence of Kyanite schist,Garnet mica schist quartzites and para amphibolites of Tugnath formation, it is intruded by granite at Ragsi.The main Central Thrust seprates it from Garhwal Groupof rocks.The Dudatoli Group is represented Pauri Phyllite and Kirsu Quartzite which forms the northern limb of Dudatoil syncline. The north Almora Thrust makes it boundary with Garhwal group. The later is divisiable in to Rudraprayga, Lamri, Chamoli and Gawangarh and Patrali Formation which occurs in normal stratigraphic order. It is intruded by biotite granite by biotite graninte at Nainidevi and Mohankal, with tourmaline granite around Chirpatikhal and also by basic intrusive. The Rudraprayg, Lameri and Chamoli formations are equivalent to Uttarkashi Shyalnan and Nagnithhank Formation respectively in Bhagirathi valley.

The Garhwal Group has been subjected to three phases of tectonic deformation. The south east to southerly plunging folds such as Marithanasa and Pingapani synclines Karanprayg anticline were developed during the second phase of movements. The Alaknada fault which cuts off set of the formation and earlier structures between Sunala is the strike slip fault in western part, appears to be the youngest elements.The impact of this fault is manifested in alignment of river terraces and land scape profile in Alaknanda valley. Geologically, the Bhagirathi valley and adjoining areas comprises of four distinct units namely from north to south the Central Crystalline Group , the Deoban Group the Simla Group,and Krol belt rock separating from one another by thrust or faults. The main Central Thrust passing through Sainj upstream Uttarkashi in northern part brings the northerly dipping crystalline rocks in sharp contact with under lying Deoban Group (Garhwal Group) sedimentary which comprises a lower Deoban Formation of Phyllite, slate Meta basics, minor quartzite and lime stone, the middle Deoban formation of lime stone and upper Deoban formation of Quartzite and basics. The southern contact of Deoban Group is faulted one with comprising mainly siltstone, greywacks and slates dipping south

This fault called Sringar Nalupani fault is of fundamental nature. In the southern and eastern part of the area this fault marks the contact between Deoban and Chandpur formation. In the western part south heading Ton Thrust separates the underlying Chanpur formation from the underlying Simla slates which shows abundant development of slump balls rod etc. indicating syndepositional disturbances in the basin of sedimentation; while in Chanpur formation, is manly argillaceous, becoming arenaceous towards the top. The Tons thrust passes through Laluli in Nagun Gad and is probably truncated by Tehri Nalupani fault at Chandpur in Bhagirathi valley.

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.

The area genetically comprised of terraces of three domains, viz. Glacial, Fluvio-glacia and Fluvial which represent distinct environment of sedimentation of Pleistocene, late Pleistocene and Holocene time during Quaternary period.

The Glacial terraces are identified at an average elevation of 1150 m above MSL, the fluvio-glacial terraces at an average elevation of 975m above MSL and fluvial terraces at an average elevation between 650 to 900 m above m.s.l, amidst these sdimentological studies of Alaknanda and Bhagirathi terraces in type area is attempted in to understand the nature of erosional and depositional processes, sedimentary pattern, behavior of transporting agencies, load characteristics, current capacity, energy condition to decipher over all history of Quaternary sedimentation in these valleys inI increasing antiquity.

The statistical parameters of sediment glacial terraces, Fluvio-glacial terraces and Fluvial terraces are studied down the current in Badrinath and Reshikesh section along the entire length of Aaknanda and Ganga in Garhwal Himalaya.

The average mean size of sediments of terraces of glacial domain is 0.09 Ø (Coarse sand). It varies from -2.81 Ø to 2.8 Ø i.e. the sediment consist of very coarse sand to fine sand. The maximum value of (MZ) is -2.81 Ø near the origin of the river and minimum 2.8 Ø near the outer limit of these terraces around Chamoli. The (MZ) shows sharp decrease in size in Badrinath and Vishnuprayag, section corresponding to the steep slope of river. Down the stream Vishnuprayag although it decrease in its value but display strong variation in size, which is attributed to the mixing of sediments brought by the sub-glacier joining the main Alaknanda at various points. It is a measure of sorting which reflects the consistency in the energy level of depositing medium. In respect of glacial terraces the average standard deviation is 3.34 Ø (very poorly sorted). It varies from 2.00 Ø to 4.30 Ø i.e. the sediments are poorly sorted to extremely poorly sorted. The sediments of these terraces are extremely assorted and are heterogonous in nature and multi source of their derivation.. The average (SKI) for glacial sediments is 0.064 Ø i.e. the sediments are negative skewed. It ranges from -0.450 Ø to + 0.52 Ø i.e. the sediment are negative skewed to positive skewed, which indicate the tendency of gradual decrease in value of (SKI) in upstream direction as result of retreat of glacier and decrease in the transport capacity. The 56% of the sample shows the negative value and 44% positive value. The sediments are very positive skewed to very negative skewed which seems to be due to mixing of sediments brought by various glaciers. The sediments down the stream of Badrinath have the strong tendency to be positive skewed.. The value of (KG) in the sediments of glacier terraces is highly variable. The average value is 0.716 Ø (platykurtic); whereas it varies from 0.49 Ø to 1.10 Ø (very platykurtic to leptokurtic).

The average mean size of sediments of fluvio-glacial domain is 2.15 Ø (medium sand). It varies from -2.53 Ø to 3.12 Ø i.e. the sediments consist of very coarse to very fine sand. The size distribution of these deposits in the study area is extremely irregular and erratic. The sediments near the outer edge of glacial deposit downstream of Chamoli ranges 0.75 Ø to 0.50 Ø i.e. coarse to very coarse sand which constantly show decrease in (MZ) along the stretch of 30 km up to Karanprayag. The sediments between Chamoli and Karanprayag along 45 km show range of order of 1.25 Ø to 2.75 Ø with local variation. The sudden rise in (MZ) is noticed around Nandaprayag and downstream and downstream of confluence of Alaknanda and Nandakini (MZ) values are of order of 0.50 Ø to 0.15 Ø, which indicates the intensive mixing of sediments brought from the flash stream resulting from the retreating glacier at different point in the valley..The standard deviation of fluvio-glacial sediments varies from 0.95 to 2.50 Ø i.e. the sediments are poorly sorted to very poorly sorted. The average standard deviation is 1.563 Ø (extremely poorly sorted). Out of 50 samples 8% are moderately sorted, 10% poorly sorted and 32% are very poorly sorted. The sediments near the source area conspicuously exhibit poor sorting and show significant improvement down the stream with local variation. As a whole the sediments are poorly sorted to very poorly sorted and heterogeneous in nature.

The fluvio glacial sediments show skewness ranging from -0.48 Ø to + 0.97 Ø i.e. the sediments are skewed very negative to skewed very positive. The average of (SKI) is 0.078 Ø i.e., the sediments are fine skewed. Out of the total samples of these terraces 56% are skewed positively, 16, skewed positive and 22, are skewed very negative. The assemblage of variable value of (SKI) suggests the heterogeneous association of the sediments ranging from fine sand to gravel size. The (SKI) value in general increase downstream with occasional variation. It is perhaps due to repeated reworking of the sediments towards downstream side by flash stream resulting from the glacier. The average (KG) is 1.316 (leptokurtic). It ranges from 0.76 Ø to 1.52 Ø (platykurtic to very leptokurtic) among these 75% of the sample fall in very platykurtic class 47.50 (mesokurtic) and 45, (leptokurtic). The assemblage of these different classes of kurtosis suggests the dominance of coarse sediments (Folk & Ward, 1957). Most of the samples between Chamoli and Karanprayag section along the starch of about 45 km show the Kurtosis value ranging between 0.90- 1.20 Ø except in the area around Nandaprayag Nagrasu, where the sedimentation is perhaps affected by lateral mixing of sediments brought by the sub-glaciers. It seems that sediments were transported and deposited in the oscillating kinetic condition.The average mean size for the sediments of terraces of fluvial of Alaknanda is 2.458 Ø. The maximum value of (MZ) is -0.491 Ø is noticed near Karanprayag while minimum 4.545 Ø at Deoprayag, near the confluence of Alaknannda and Bhagirathi River. The (MZ) shows the significant consistency in its value in the first stretch of about 35 km between the Karanprayag and Nagrasu, corresponding to the flattered and gentle slope of the river bed. Down the stream of Nagrasu for about 75 km up to Deoprayag (MZ) sharply decreases perhaps due to sharp change in bed slope of Alaknanda. In this section (MZ) strongly fluctuates around Kaliyasour, Srinagar and Kirtinagar for about 25 km which correlated to the sudden convexity in the river bed due to Neotectonic activity in the vicinity of Srinagar fault/ North Almora thrust, which traverses across the Alaknanda around Kaliyasour.It seems that the mean size of fluvial sediments sharply follow the bed slope, pointing to exponential longitudinal profile, thus decrease in (MZ) in the downstream of the Alaknanda is result of decrease in both transporting capacity and velocity of the river towards the later phases of sedimentation in the valley.

The average standard deviation of sediment is 0.691 Ø (moderately sorted) and it ranges from 0.15 Ø to 1.52 Ø i.e. the sediments are very well sorted to poorly sorted. In the upper Alaknanda, it shows consistency in value down the current except around, Karanprayag and Rudraprayag, where Nandakini Pindar and Mandakini joined Alaknanda respectively. The variation in and around these places appears to be due to mixing of sediments brought by these tributaries. The sharp improvement in sorting is noticed downstream of Rudraprayag upto Srinagar which seems to be related with the repeated reworking of sediments and slope element. The sudden decline in sorting coefficient in the stretch of about 15 km between Srinagar and Kirtinagar appears to be due to either the non-transport of larger grain down current or due to loss of bed slope of Alaknanda in this segment of valley. The significant increase in sorting in down current of Kirtinagar indicates cyclic reworking of sediments appears due to re-activation of channel in this part of valley. The average (SKI) of fluvial sediments is 0.00281 Ø It ranges from -0.99 Ø to 0.99 Ø i.e. the sediments are coarse to fine skewed. The (SKI) exhibits tendency of gradual increase in value downstream with local variation. This suggests relative increase of fine grains, down the stream. The sediment upstream of Karanprayag is negative skewed perhaps due to mixing of sediments of fluvio glacial origin.The kurtosis of fluvial sediments of Alaknanda is highly variable; it ranges from 0.72 Ø to 1.72 Ø (leptokurtic) and an average value 1.264 Ø (platykurtic to very (leptokurtic). The average values suggest the fluctuation in the energy condition of the channel system. The mean value of kurtosis revealed the more intensive sorting of central part of size distribution curve than the tails. Along the course of Alaknanda in Nadaprayag and Deoprayag section for a distance of about 75 km except local variation around Karanprayag, Rudraprayag, there is strong tendency in increase of kurtosis value downstream.

The longitudinal profile of Alaknanda River and its terraces of various domain is overall concave, smooth and gentle, except in the area between Karanprayag, Dharkot, Rudraprayag and Kaliasour, where it is slightly upward convex. The gradient of the river between Chamoli and Karanprayag is 1:6.6, between Karanprayag to Rudraprayag 1:2.25, and between Rudraprayag and Srinagar is 1:1. The average gradient of terraces AT_1, to AT_6, between Karanprayag and Dharkot and Dharkot and Kaliasour is 1:2.29, 1:1.66, 1:1.87, 1:2.20 and 1:1.25, respectively. The upward convexity in the area as mentioned above indicates some differential up warping of some of the terrace blocks possibly due to some movements along the Srinagar-Tehri Fault/Alaknanda Fault (Sinha & Khan .1975, Khan 1981).The profile of terraces of glacial domain is restricted up Chamoli and is of hanging in nature , whereas of fluvio-glacial terraces mostly confined to the upstream of Karanprayag, it pinches out downstream against the terraces of fluvial domain, thereby indicating an intensive down cutting of the valley floor by Alaknanda through cyclic rejuvenation consequent to recession of in post Pleistocene time. The profile of glacial terraces demonstrate intensive dissection of terraces and isolated pockets and lenses of occurrence at higher level in the valley and profile is of is of changing in nature, whereas of fluvio- glacial is of suspended in nature and suddenly abuts up stream against the profile of glacial terraces and downstream against the profile of fluvial terrace. Down the current profile of fluvial terraces display consistency and and smoothness down the current. The profile of fluvio-glacal terraces represent transitional phase of sedimentation and major in Quaternary time the valley.

The longitudinal profile of Bhagirathi is over all cancave except in the upper reaches between Seansu and Bhatwari, where the upward convexity in the alternate segment is very conspicuous. The upward convexity and development of nick points, corresponds to major tectonic elements, Main Central Thrust (Khan et.al. 1982 1988). Srinagar Nalupani fault and Tons thrust in the area. The gradient of the channel bed in upper Bhagirathi in Bhatwari Uttarkashi section is 1:1.98, in Uttarkashi Dharasu section 1:1.75, in Dharasu-Tehri 1:1.55 and Tehri and Devprayag 1:1.20. The profile of domain of glacial terraces extends up to Gagnani and Fluvio-glacial terraces up to Nakuri and down the current profile Fluvial terraces is gentle and smooth and in conformity of river bed. The profile of glacial terraces is of hanging in nature, whereas of fluvio- glacial is of suspended in nature and fluvial display consistency and regularity down the current. The profile of fluvio-glacal terraces represent transational phase of sedimentation in the valley.

The study of geology ,geomorphology, Quaternary terraces and landscape profile section revealed that there is sharp curvilinear break in morphogenetic expression of the area, North of Wazri in Jamuna valley, North of Uttarkashi in Bhagirathi valley, around Tugnath and Chamoli and South of Joshimuth in Alaknanda valley, which is significant element, appears to be due to horizontal movement of a sub - tectonic plates towards south., It may be causative factor in dislocation in tectonic ecology of the area, related to recent micro shocks in Joshimuth in Niti and Hellong area mass failure of landscape profile, landslide and mass wasting activities and other natural hazards; it is matter of serious concerned and needs further attention

The study of Statistical parameters and their correlation with various Thrust, fault, lineament and longitudinal profile of Alaknandaand its tributaries, revealed that there is strong impact and influence of tectonic and Neotectonic activity on Quaternary sedimentation in the area..

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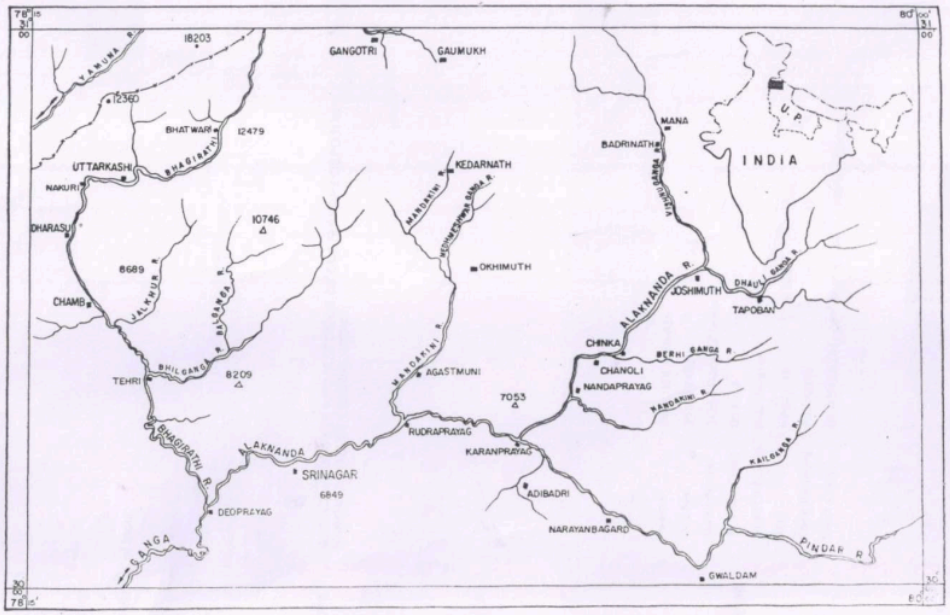
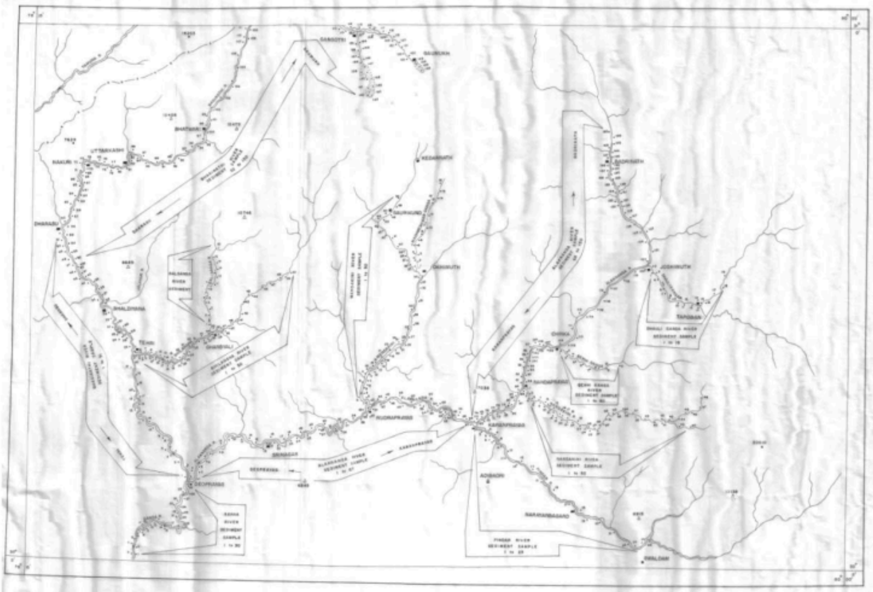
KEY MAP OF ALAKNANDA AND ITS TRIBUTARIES

GARHWAL HIMALAYA U.P.

Plate No_1



MAP SHOWING LOCATION OF SEDIMENT SAMPLES COLLECTED FOR SEDIMENTOLOGICAL STUDIES
IN ALAKNANDA AND ITS TRIBUTARIES, GARHWAL HIMALAYA, (U.P.)



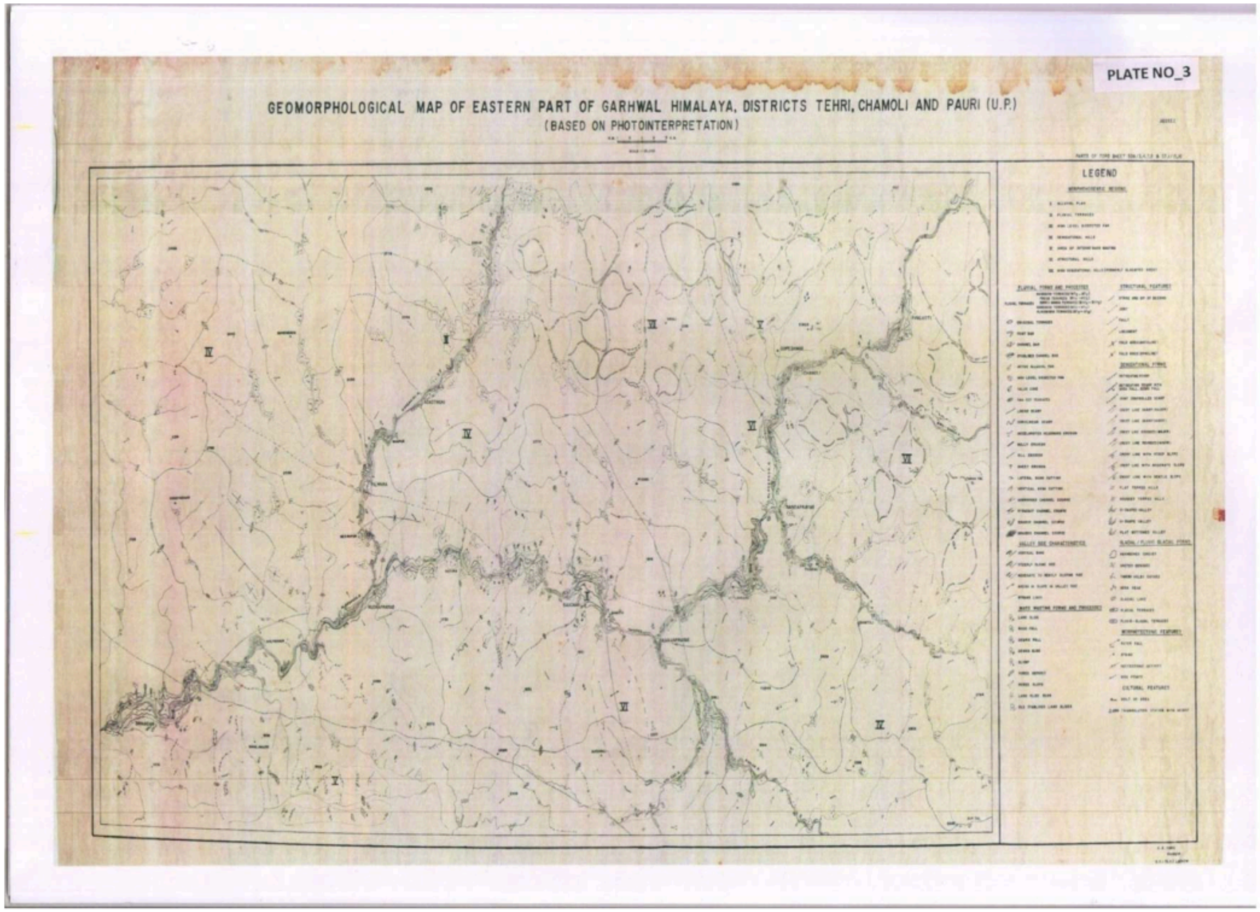


PLATE NO_3
GEOMORPHOLOGICAL MAP OF EASTERN PART OF GARHWAL HIMALAYA, DISTRICTS TEHRI, CHAMOLI AND PAURI (U.P.)
(BASED ON PHOTOINTERPRETATION)
LEGEND

PLATE NO_7

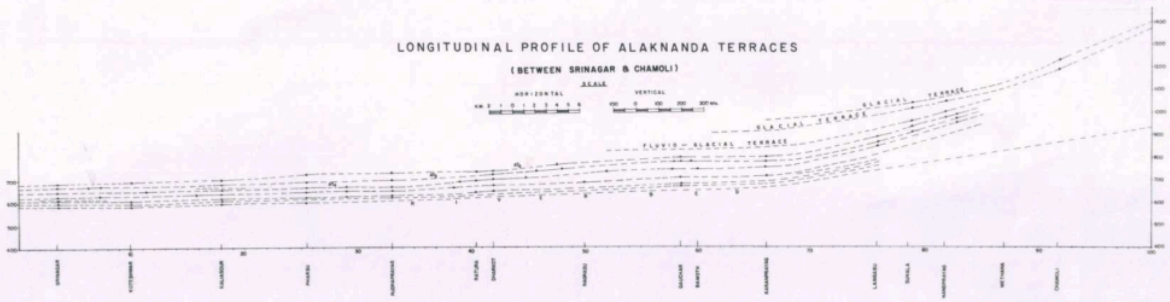

LONGITUDINAL PROFILE OF ALAKNANDA TERRACES
(BETWEEN SRINAGAR & CHAMOLI)
SCALE
HORIZONTAL
VERTICAL
GLACIAL TERRACE
GLACIAL TERRACE
FLUVIO - GLACIAL TERRACE

PLATE NO_8

CROSS-SECTION OF FLUVIAL TERRACES IN TYPE AREA IN ALAKNANDA AND ITS TRIBUTARIES, GARHWAL HIMALAYA (U.P.)

VERTICAL SCALE : 1 Cm. = 100 Metres
HORIZONTAL SCALE : 1 Cm. = 250 Metres

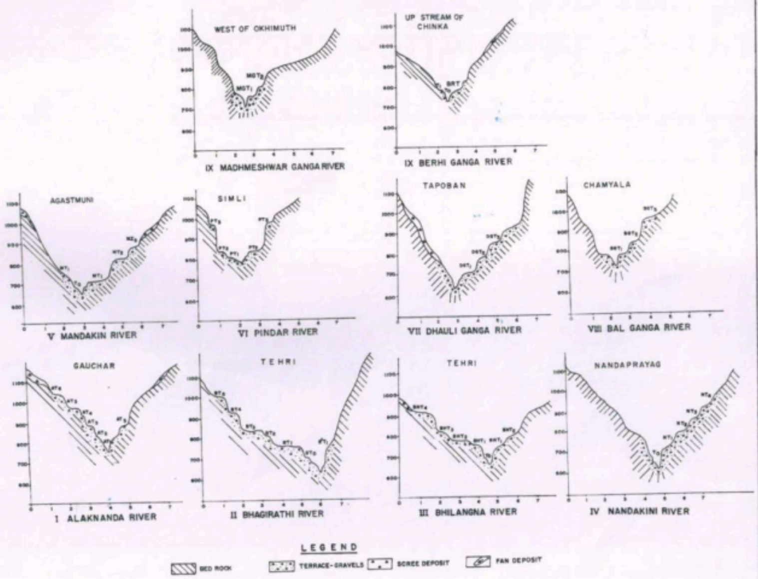


Plate No_6

DIAGRAM SHOWING LONGITUDINAL RIVER PROFILE AND VARIATION IN STATISTICAL PARAMETERS IN QUATERNARY TERRACES OF FLUVIAL DOMAIN, DOWN THE STREAM - NANDAKINI VALLEY, GARHWAL HIMALAYA, (U.P.)

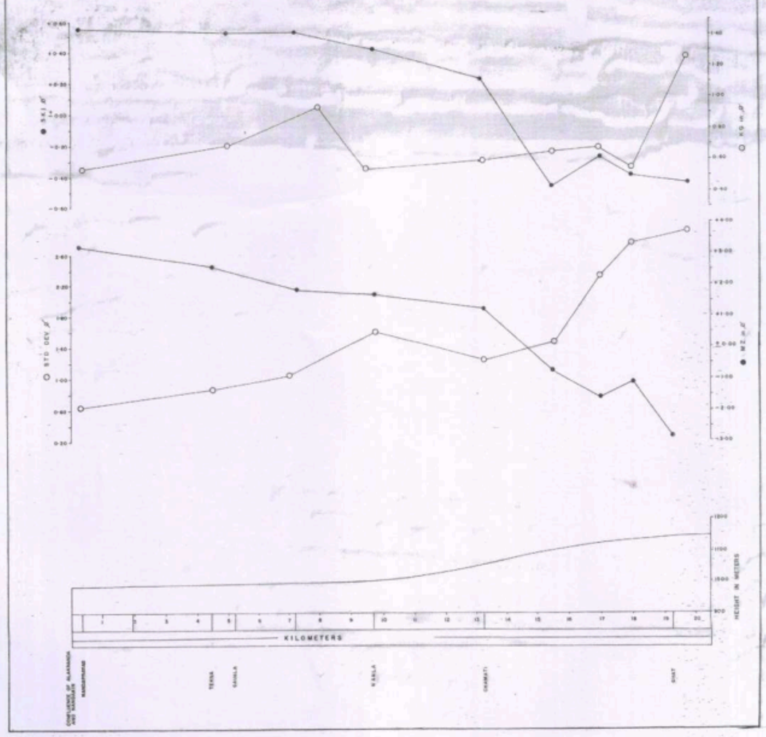


Plate No_7

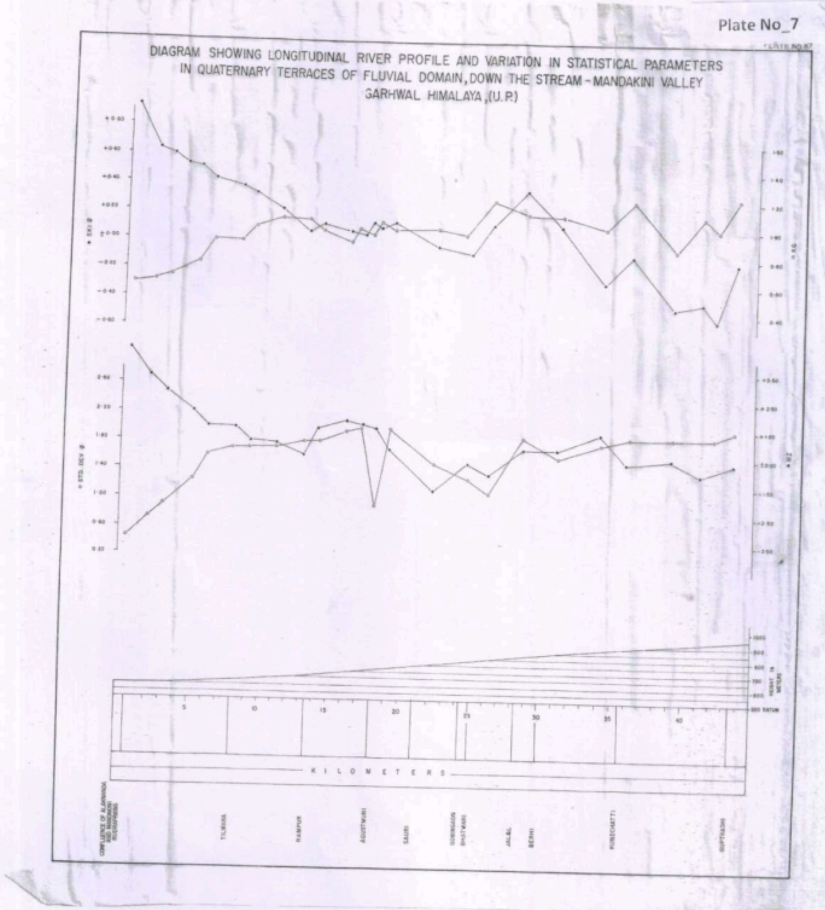


DIAGRAM SHOWING LONGITUDINAL RIVER PROFILE AND VARIATION IN STATISTICAL PARAMETERS
IN QUATERNARY TERRACES OF FLUVIAL DOMAIN, DOWN THE STREAM – MANDAKINI VALLEY
GARHWAL HIMALAYA ,(U.P.)
K I L O M E T E R S
TILWARA
RAMPUR
AGUSTMUNI
SAURI
JALAL
BERHI
KUNDCHATTI
GUPTKASHI

Plate No_8

DIAGRAM SHOWING LONGITUDINAL RIVER PROFILE AND VARIATION IN STATISTICAL PARAMETERS IN QUATERNARY TERRACES OF FLUVIAL DOMAIN DOWN THE STREAM - BAL-GANGA VALLEY, GARHWAL HIMALAYA, (U.P.)

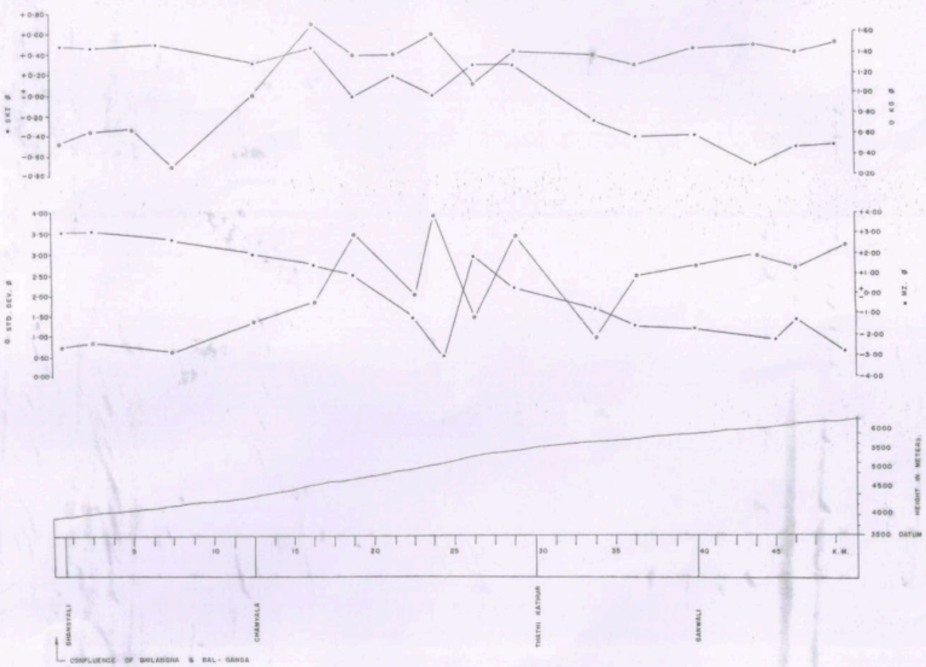


Plate No_9

DIAGRAM SHOWING LONGITUDINAL RIVER PROFILE AND VARIATION IN STATISTICAL PARAMETERS IN QUATERNARY TERRACES OF FLUVIAL DOMAIN, DOWN THE STREAM – PINDAR VALLEY, GARHWAL HIMALAYA (U.P.)

Plate No_10

DIAGRAM SHOWING LONGITUDINAL RIVER PROFILE AND VARIATION IN STATISTICAL PARAMETERS
IN QUATERNARY TERRACES OF FLUVIL DOMAIN, DOWN THE STREAM
MADHMESHWAR GANGA VALLEY, GARHWAL HIMALAYA, (U.P.)

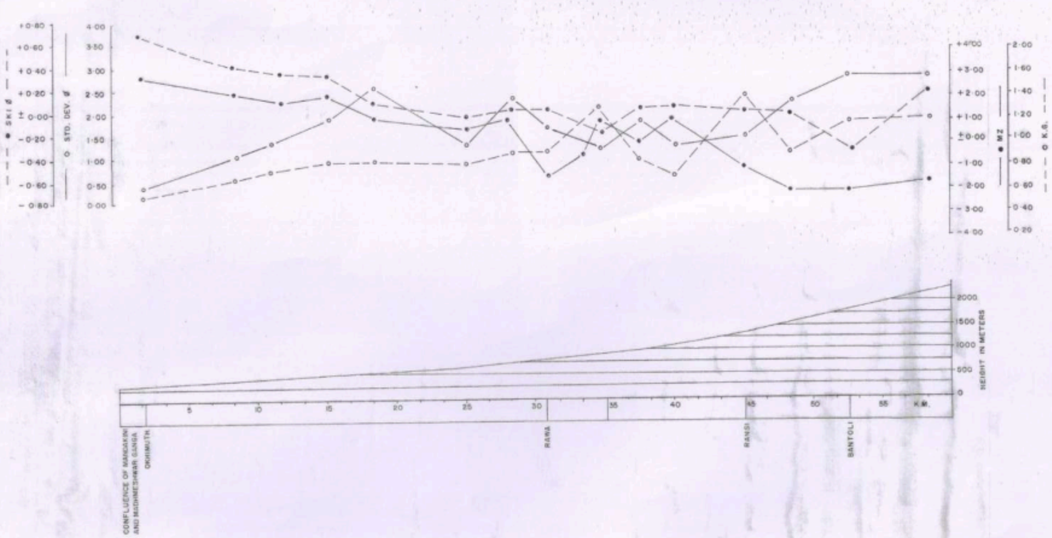
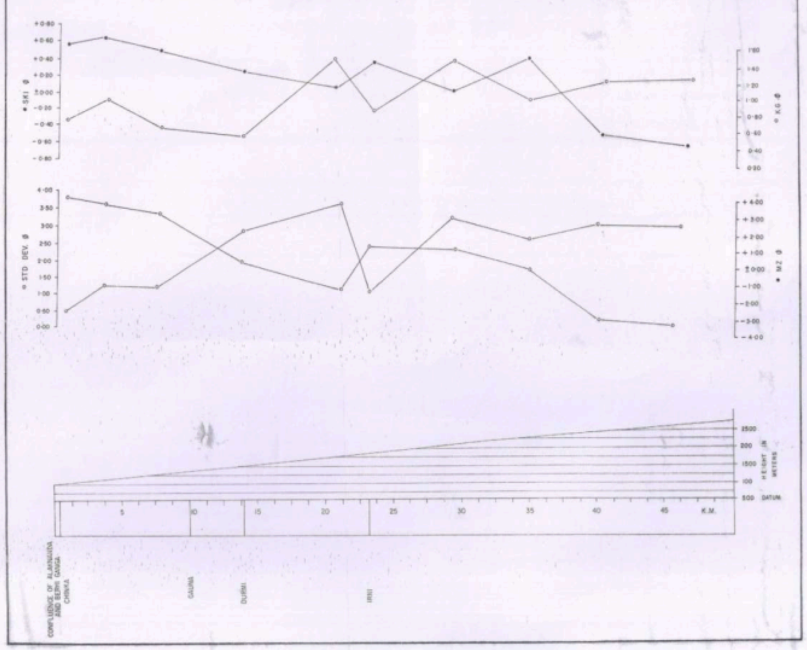


Plate No_11

DIAGRAM SHOWING LONGITUDINAL RIVER PROFILE AND VARIATION IN STATISTICAL PARAMETERS
IN QUATERNARY TERRACES OF FLUVIAL DOMAIN DOWN THE STREAM-BERHI GANGA VALLEY
GARHWAL HIMALAYA ,(U. P.)



QUATERNARY TERRACES OF DIFFERENT DOMAINS OF ALAKNANDA & ITS TRIBUTATIES, BEHAVIOUR OF STATISTICALCAL PARAMETERS DOWN THE CURRENT IN BADRINATH _RESHIKESH SECTION, GARHWAL HIMALAYA, UTTTRAKHAND STATE IN

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