Impact of Neotectonism in the Discussion of Geomorphological Processes as a Feedback System: North Bengal Foothills, West Bengal

Mery Biswas

Abstract -- **The ongoing research paper is concerned about the sensitive issue like neotectonism and its impact on the landscape development. It is a detail and micro level study of North Bengal Himalayan foothills where the effect of tectonism is precisely observed. The term, neotectonism was introduced by Obruchen (1948) to summarize the active tectonic processes including the last major tectonic configuration change and establishment of modern stress. The North Bengal Himalayan foothill area is very much concerned about the neotectonism activities from last to present geological periods. It is the one of the active unstable areas of NE India where faults/thrusts and presence of synformal axis are predominantly controlling the geomorphological landscape development. This frontal region is a part of an active orogenic belt like the NE Himalaya and characterized by complex terrace morphology with fluvial aggradation, degradation and strath terraces. The detail study is mainly about the lineaments, drainage sequences, thrusting zone and synformal depressed zone of the area. Near the Neora-Mal river valley, close to the mountain front a thick supported boulder bed with huge angular boulders of gneisses are exposed near Neora valley of Samsing area. Concerning the fault zone area of Matiali scarp, it is very clearly observed the extended part of Garubathan thrust (MBT) under the Matiali formation near the upper part of Kurti river. But, in the middle part of the river, where the synformation axis is present, river terraces are magnificently developed over two sides of R. Kurti near Matiali hat. Here, two terraces are well virtualized but the upper most flat terrain is designated as fan surface which is made of mainly by the deposited sediments of Matiali formation. In this region, slope of the fan surface is southerly 2.1°. In south of the Matiali scarp on the banks of R. Neora, Kurti, Murti raised terraces are distinctly observed as T1 and T2.These kinds of features have developed due to the active tectonic movements from last Pleistocene to recent Holocene. As an evidence , we can consider the recent seismic study with in meizoseismal zone of both the 1934 Bihar-Nepal and 1950 Assam earthquakes but last surface rupture with a recorded displacement of 14m of Chalsafault related to the historical earthquake in Nepal around 1100 AD (Kumar et.al. 2011). It is a positive feedback system where neotectonism and geomorphological landscape are well related and in a classical model of fault propagation; geomorphic evolution through the structure/process is present in respect of time and space.**

Keywords -- Neotectonism , Landform , Topography

I. INTRODUCTION

The term Neotectonics was introduced by Obruchev (1984) to summarize active tectonic processes. Later, the definition was wided to include all tectonic processes since the major tectonic con figuration changes. The history of deformed terrain required the determination of relationship between tectonism and related topographic expression in terms of geomorphological significance of the area. It is mainly concerned about the multi-scale of structural sequences through time. The progressive sequences of deformation as multiple thrust zones are well defined in north Bengal foothills areas where geomorphic architeclines one distinctly expressed by both the action of endogenetic and exogenetic forces. This may be effectively and scientifically used to work out kinetic evolution of entire fold and thrust belt. This structural control and multi cyclic evolution has helped to develop such a geomorphic terrain. Numerous minor structural controls with the pressure of thrusts and faults are occurred over the entire area of Chel-Murti foothills areas. Changing in the different tectonic factors, which characterize the evolution of the Mal-Chalsa area. But this leads to the definition of a 'transitional time interval' where in both kinds of periods like "palaeotectonic" and

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"neotectonic" are present. This transitional time interval depends on the regional geographical evolution. This regional evolution has happens to be continued through the quaternary to resent piedmont deposits. Widen their valleys and build up a new flood plain at a lower level (more or less at the same level as the fan surface on the T3) . In the next phase the movement raised the fan surface and t3 up to 60 m.

II. OBJECTIVES

So far the work on tectonism has been done in macro scale and the effect of tectonism not clearly analyze and evident in North Bengal Foothills.Regarding this, the major and primary objectives are:

i. Identification of Neotectonism activities in micro scale.

ii. Detail geomorphological evolution and analysis of landscape deformation processes in respect of tectonism.

III. LITERATURE REVIEWED

The Chel-Murti region has been considered as the areas of attraction for several years as it is a transitional zone between the hill and plain lands. Between the years 1764 and 1777, Rennel made his survey followed F.R. Mallet and in the later stage by eminent personality. The first physiographical account of this part of North Bengal terrain adjacent to the Darjeeling-Bhutan foothills dates as recent as in 1971 when Acharya (1971), provided valuable informations about the Shumar formation of S.W. Bhutan, Maity (1980), Shina Roy (1981), Bagchi and Mukherjee (1983) have described very briefly the geological formations including broad lithological characteristics of some parts of the Darjeeling and Jalpaiguri districts of West Bengal and Bhutan foothill. This was by way of introduction. The present paper is a details study of geo-morpho-tectonic arguments which is carried by the author through steps. Goswami (1973-1986), Mukhopadhyay (1978, 1982), Chottopadhyay and Das (1979), B.S. Singh presented at the 22nd International Congress, New Delhi). The records and memoirs of G.S.I. of which they were the authors. Subsequently, Mukhopadhyay (1982), Bagchi*et al*. (1983), Roy (1992) and others have analyzed very briefly the fluvio-geomorphological and pedological features of the major river valley areas and adjacent regions. They have touched upon touched about the general outlook of the area. Actually they have done a descriptivewritings but this author has endeavored to prepare a comprehensive analysis of landform deformation in Neotectonism response.

IV. METHODOLOGY

To fulfill the aforesaid objectives this worker has adopted the modern methodology including the Remote Sensing and GIS, employing appropriately the relevant data, information and evidences and intensive field work with particular environmental and geomorphological interest. This dynamic interfluve area seismotectonically known as active zone of complex neotectonic framework. Most of the analysis of the study is based on intensive field work, data collection and empirical observations in terms of- (i) pre-field, (ii) field and (iii) post field methods with an application of advanced techniques of measurement and analysis. The first phase includes the collection of data, preparation of maps like hydrological, drainage and data base maps concerning primary and secondary sources. This piece of study The present paper is a details study of geo-morpho-tectonic arguments which is carried by the author through three steps-

A. Pre-field work-accumulation of knowledge about the geological and tectonical evolution of north east India including Tista-Torsha foothills.

B. Field work- perception of tectonisms and landform analysis with measurements. It includes Total Station survey on terraces and sediment layer analysis of Metiali Fan and Kurti river.

C. Post field work- involves data computation and presentation with the help of Arc GIS 10.1 and Erdas Imagin9.2.

V. DISSCUSSION

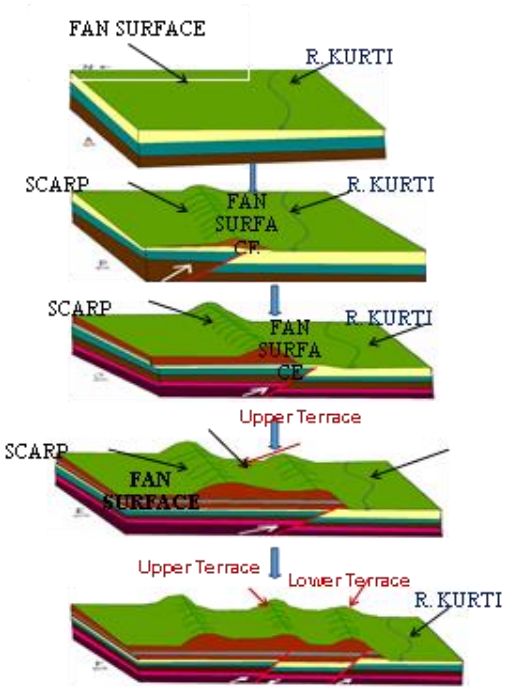


Fig. No. 1 Evolution of the area through geomorphic land deformation

Formation of alluvial fan at the mountain front started from sometime during Late Pleistocene and grows southward.First movement occurred as Metiali thrust with the formation of ramp Anticline and incision of Garubathan thrust.After the cessation of the movement, the incised rivers and the River Kurti had incised the valley by vertical erosion the scarpheight increased up to 60 m and the river cut out.

Similar two cycles of erosion took place and the river deformed the valley. With the formation of T2 and T1. Normal faulting along the Neora, Murti and Mal lineaments has downthrown the Neorae Mal inter fluvial block and the block east of the Murti river.Neotectonisms and geomorphological evolution of the study area is a positive feedback system where geology of Himalayan hedge area of North Bengal portion is paying an important role. The geological structure or formation is mainly considered as quaternary deposits of Chel-Neora-Jaldhaka valley slope towards south. Form south to North the expansion of foothill mains are formed by the Baikunthapur formation which is overlain by Chalsa, Metiali and Samsing surface (Fig.no.2) is the north. Here the elevation has deceased to 600m in the mountain front to 150m within a 20km long distance from north to south. The Chalsa scarp near ChalsaMahabari village is the formal.

TABLE NO.1 DETAIL GEOLOGICAL FORMATION

Formations	**Weathering Zone**	**Soil Zone**
Shaugaon Formation	Unoxidised	No soil cover
Baikunthapur Formation	Do	Black soil cover
Chalsa Formation	Yellow coloured sediments	Brown soil cover
Matiali formation	Orangedcoloured sediments	Red soil cover
Sumsing Formation	Red coloured sediments	Chocolate soil cover

Southern boundary of this deposits. But, it is extended to Borodighi village as Borodighi fault scarp (HFF) of 90m-110m elevation. If we consider the geological sediments deposition, there are five types of deposition. The geological section of is showing-Clay sand deposit → pebble deposits with sand lenses → pabbledeposis→boulders with sand particles→sarie size boulders → unsorted boulder. But it is found to be observed that unsorted boulder deposit is absent from the Metiali fault to Chalsa fault zone.

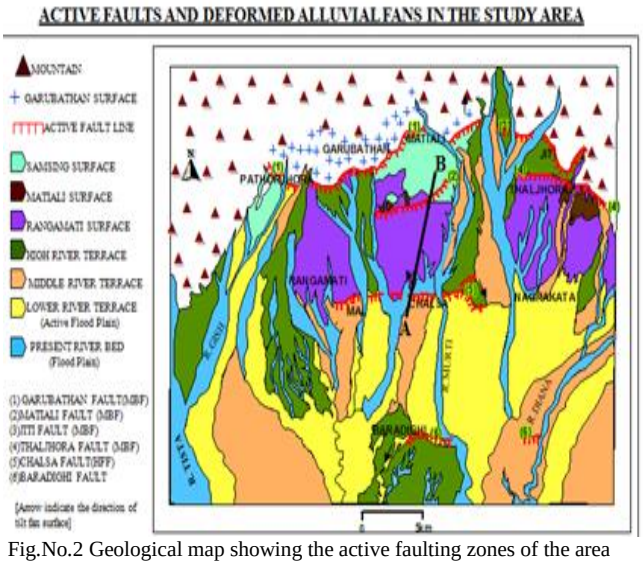


Fig.No.2 Geological map showing the active faulting zones of the area

Actually the piedmont deposits near to the mountain front, a thick-clast-suported boulder bed with huge angular boulders of gneiss is exposed. This is referred to be the fan head i.e. Samsing formation. Next to the downstream sheet like sand masses and dominantly grame deposits are noted as Metiali formation. But in the Jaldhaka upper part valley, the fan head material isabsent. In 1993 Das and Chattopadhya and the present author have coined up some significant geological deformation as both the Rangamati and Metialiformation are under the single geological entity and modified by variant alluvial fans where there fans are conjugated to each other or overlapping from north to south. Regarding the pedological constraints, Samsing formation is the oldest one.

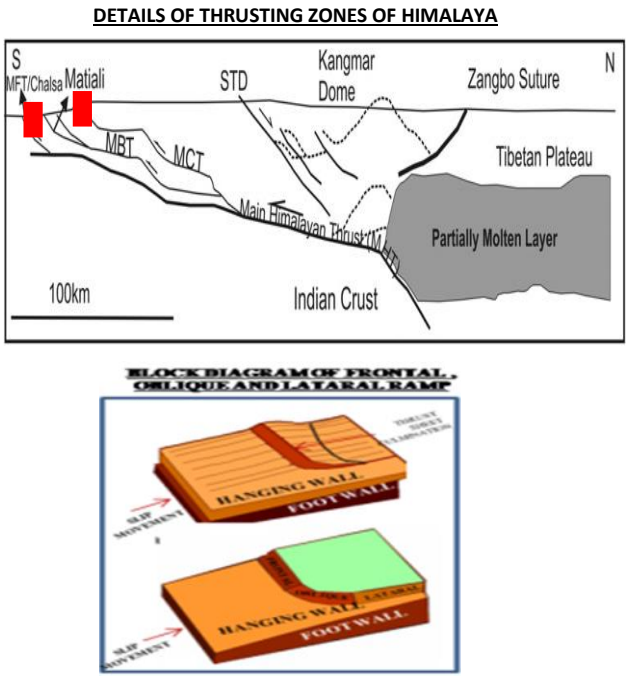


Fig. No.3 Detail map of Thrusting zones of Foothill and nature of slip

VI. TECTONIC SCENARIO

The present author has also considered the lineament; drainage analysis is respect of landscape evolution. The total study is purely based on some empirical observation, fieldwork, satellite data analysis in thrust-fault identification and also some part of image processing through GIS softwares.

A. Lineament Analysis

The present study deals with the discussion of the general geological features stressing much on the stratigraphy of Tectonic Belts relating to Litho-structural characteristics of the North Bengal plains. The present study has been undertaken to unravel the various geological features encountered in studying the Quaternary fluvial deposits and landforms of the area. Since 1970, a gamnt of scientific information on the Quaternary deposits have been collected and till the end of sixties post Neogene Sediments in India were classified into two groups; 'Lateritic' and 'Alluvium' of Quaternary age. Among the Quaternary Geological formations of Eastern India, this study area has involved polycyclic landscape and peculiar drainage system, being reconstructed from time to time.The basic of neotectonic activity and the distribution of lineaments is well deformed by the drainage pattern of the area.The geological formation along with the degradation processes are well designated by the formation fluvial landscape evolutions of the Metiali area.

DETAIL MAP OF LINEAMENTS OVER THE AREA

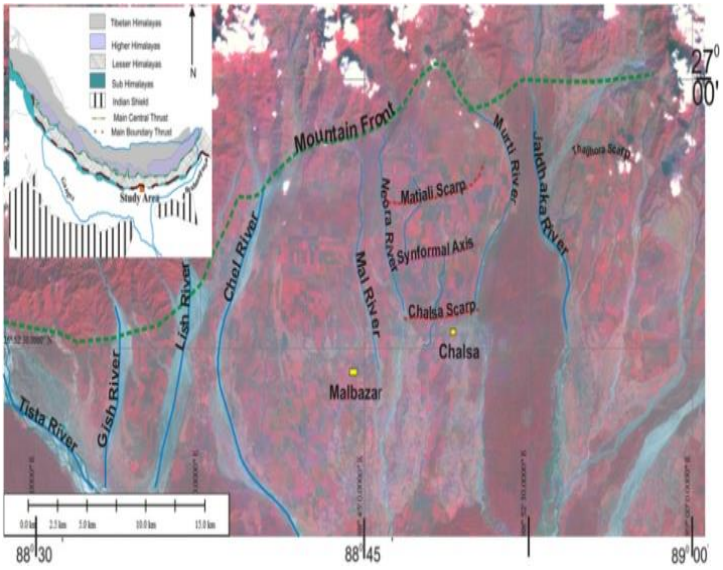


Fig No.4. Lineaments and fault scarps of the area

At the northwestern fringe of the Matiali block, on the east bank of the Neora River, one of the propagating thrusts of the Himalayan FTB is exposed (Gorubathan thrust or GT, Fig. 1c). Nakata (1989) termed this as Gorubathan fault. Here, the Precambrian Daling Group of

rocks is thrust over the Matiali Formation along a low, northerly dipping thrust plane.

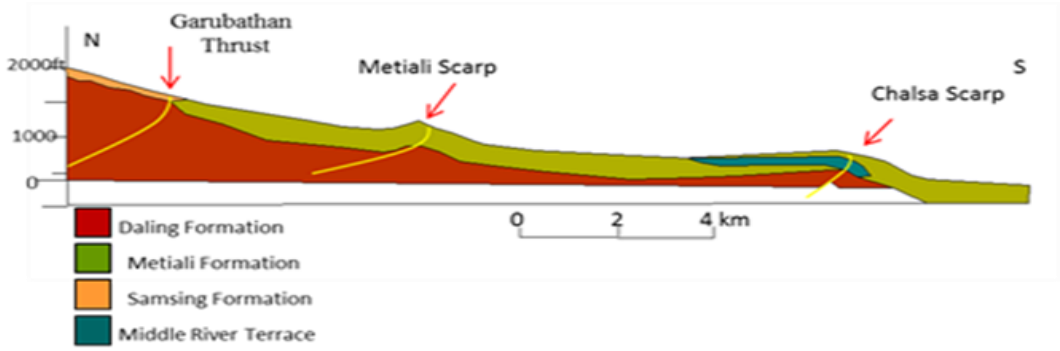


Fig.No.5.Geological section from N-S

B. Drainage Network:

Drainage Network analysis is another tools of measuring neotectonism. Because in this active unstable zone, streams/channels are starts with the individualization of areas of sub homogeneous drainage pattern.

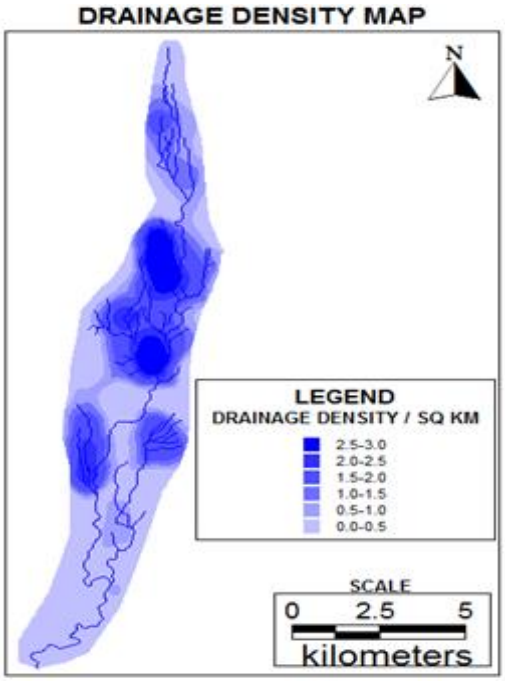


Fig. No.6 Drainage Density map showing higher value in middle part due to thrusting

All divisions from a Dendritic pattern or flow direction oblique to the regional topographic gradient or sudden turns up of channels/or segments of tributaries are considered as drainage anomalies related either tectonic or lithological. Following the drainage density map, value of DD (Fig. No.6) has increased near the Synformal zone and decrease towards south higher value near the Synformal zone.The segment of drainage anomaly is strongly found near Metiali head where the synformal axis has controlled the sudden west ward bending (Fig No.7) .It denotes that this structural slip of depression is responsible for such channel network. Just to the south of this bending if rivers, two tire river terraces are well deformed by fluvial action as exogenetic force and tectonism as endogenetic active. In the upper part of R.Neaora.

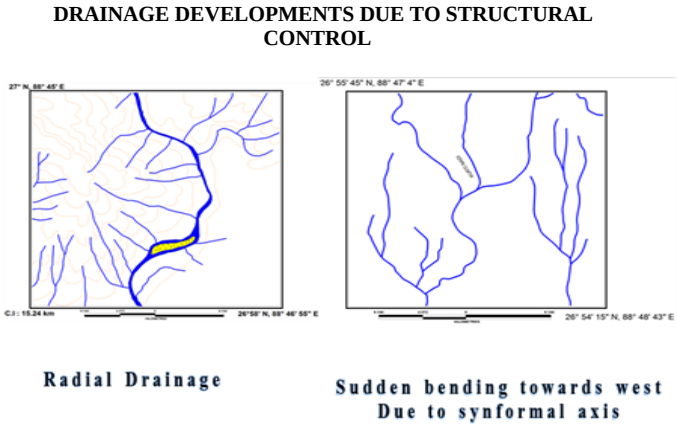


Fig No.7 Evidences of Neotectonism from Drainage orientation

Radial drainage pattern has developed due to also the neotectonic activity. The presence of paleochannel and shifting nature of R. Neora and other like Mal, Murti, Chel also denote the tectonism. The composed of quaternary sediments and it a representation of coalesced alluvial fan and between Mal and Murti river, the area is identified as a distinct alluvial tan with a radial drainage pattern and convex upward transverse profile. The radial drainage pattern of Metiali block area is modified by later tectonism because of which the streams have rejuvenated and the two tire river terraces have developed bellow the fan surface. The pedogenetic character of the fan surface is 33875±550 BP from a Clay bed on the bank of the upper reaches of Neora river and 22,030±130BP oforganic rich Clay bed of further down stream of river kurti near Chalsa.The shifting channel of R.kurti has also been identified near Metiali scarp (Fig No.7.1) which is the result of tectonic movements in recent times.

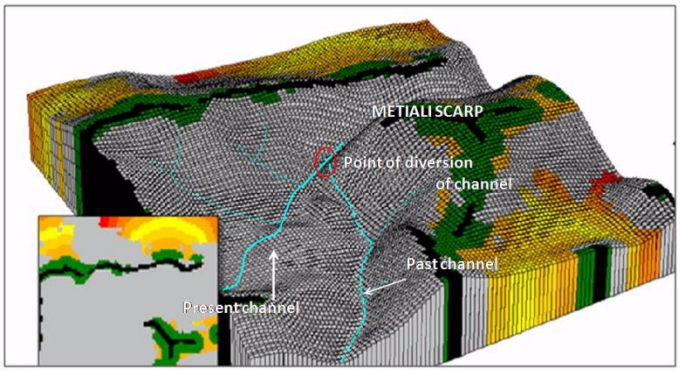


Fig No.7.1 Evidences of Neotectonism resulting channel shift of R. Kurti

There are another types of drainage irregularities are found, i.e. the river piracy. River piracy is occurred due to the rapid head ward and erosion of any river which has high energy than another one but both are originate from same water divider. If we consider the source area of River Chel and R. Mal several tectonism activities area found.This area is under the MCT 2 zone where the Chel is captured by Mal as the river has gained more energy to headward erosion and due to fracture, cracks, and joint the process has become easy. As an evidence, the wide valley and narrow channel is observed which is .absent in Mal River. Some paleochannels have also developed because of the cannel shift of river Neora. The tectonism activity is responsible as well as climatic changes of the area.

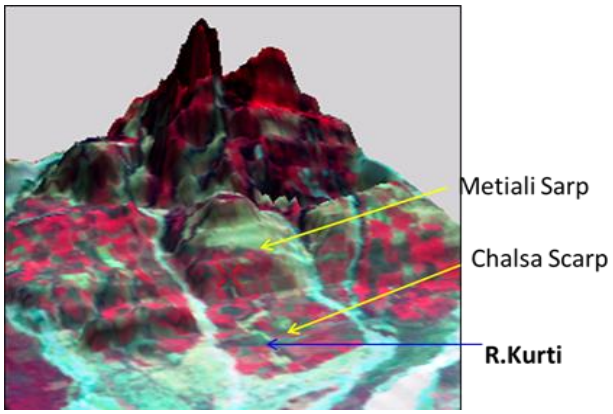
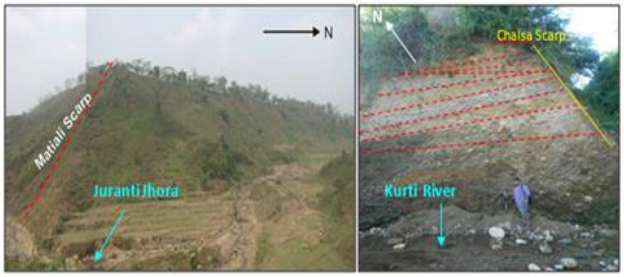


Fig No.8 Evidence from image analysis

C. Measures of Neotectonism

Neotectonism mainly refers to the unstabelity and tectonic activities of an area. It is mainly concerned about the lineaments and drainage requires, channel patterns etc. The Himalayan foothills of Mal Bazar and Chalsa area are a representation of an area where shikim is not present. The hill treats of Garubathan front, Samsing area are the part of Lasser Himalayan and geologically very significant as it is a trusting zone of MBT and within the Himalayan province/extended roots of Himalayan Gandowana thrust is well identified. Somewhere sudden decrease of slope represents the fault carps. These elongated belts of foothills are well manifested by several faults, which are somewhere parallel to the Himalayan and somewhere transverse to Himalayan. The middle part of Chel river fault scarps are well designated in the write hand site part where are tectonic flat land has well formed. This active area is experiencing landslides along the road towards Lava and alluvial cone like formations are exposed with unsorted boulders, pebbles etc. The area is geologically composed of Quaternary formations up to the hill border but the upper part of Gorubathan is under Pre-quartenary formation. The piedmont deposits display distinct litho-facies variations from the mountain front of Gorubathan to the plain of lower part of Murti River. Near the Neoro-Mal river valley, close to the mountain front a thick supported boulders bed with high angular boulders of gneisses are exposed near the Neoro valley Samsing area. Actually the metamorphisms here occurred due to the thrusting of Gondowana series and as and evident coal seam is found in Pathorjhora T.G village of Mal Block. This lignite type of low quality of coal is used by the local people and it is discontinuously extended up to

Torsa River. This area is referred as fan head which is termed as Samsing formation. According to the Das and Chattopadhaya the samsing formation is the oldest unit of highly oxidized with chocolate red soul cover and high elevated. Further downstream area is dominated by Metiali formation but in the Joldhaka valley fan head materials i.e. Samsing is not. Regarding the details study, it has been updated that, Siwalik is not missing, the stratigraphic unit of upper, middle and lower Siwalik (Sinha Roy,1967, Matin and Mukul 2000) of Cenozoic Mo-Pliocene are not exposed. But west of Grish transverse fault of Tista section it is identified as multi boulder bed of immature conglomerate and near the south Kalijhora thrust middle Siwalik is made of course grained sandstone and shale. This range of Siwalik is not exposed expect near the Chalsa and Borodighi area where due to HFF unsorted boulder beds of different shapes-sizes are sandstones one visualized. This complexity lies in both the topography of the surface as well as within the sediments the recent seismic study shows though this area is within meizoseismal zone of both the 1934 Bihar-Nepal and 1915 Assam earthquake, but the last surface rapture with a recorded displacement of 14 meters of Chalsa fault (Plate No.4) .



PlateNo.2. Matiali Scarp near Juranti jhora Plate No.3. Exposed beds of Chalsa scarp

PlateNo.4 Garubathan thrust overlain by Metiali Scarp

Considering the fault area of Metiali scarp (Plate No.2), it is well virtualized that the intended part of Gorubathan thrust. In the Gorubathan area the equivalent of main boundary thrust is named as Gorubathan thrust-in Jaldhaka area as Jiti fault and near the Tista section named as north Kalijhora thrust. Matin amd Mukul (2010) and also the present author have identified the active neotectonic zone of foothills have deformed by six stages of structural formation and they are over lapping by Gorubathan thrust. It is very clear from the field study that the both extensional fault and thrusts are active in the quaternary piedmont area of the eastern Himalayan zone and HFT is commonly designate as blind thrust and folding with in the quaternary.

LOCATION OF MATIALI AND CHALSA FAULT

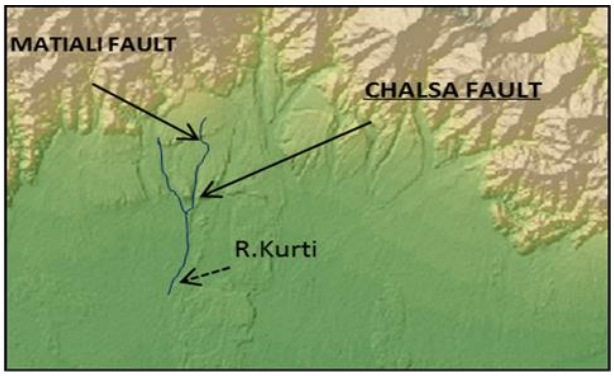


Fig.No.9. Location of Matiali and Chalsa Fault

VII. GEOMORPHOLOGICAL EVIDENCE OF NEOTECTONISM

In quaternary times Himalaya has been dominated by increasing of elevation of highest. The deeply incised natures of the quaternary deposits have increased the local erosional activity of rivers and it is well manifested and leads due to the presence of active faults and thrusts. This nature of down cutting and rejuvenated natures of rivers being controlled by the structural consequences are the noticeable offsets of gradients. It is well notified that two cycle of erosion have taken place which is evident as two river terraces in synformal zone near Metiali hat. The southernmost Chalsa thrust represent the present position of Himalayan foreland-propagating thrust front. The height scarp face is present in Chalsa. The scape losses its elevation both is west and east. sediments.

The geomorphology of western part is controlled by Neora valley incision and the eastern part near Nagrakata, it becomes sub horizontal. This is found that two tire terraces below the fan surface along the R. Kurti have developed in the synformal depressed zone but between north of this zone and south of Metiali scarp/thrust, terraces is absent. The R. Kurti is flowing through its own channel with sleep 90° angle river bank in both sides. The upperpart of river Kurti have strongly done a vertical down cutting forming the narrow 'V' shape valley (Fig.No.10) and near the oblique ramp of the hanging wall of the thrust, Deeping beds of Grubathan thrust is observed below the Metiali formation. On the west bank of Kurti river, north of Chalsa scarp, a sequence of alternating Plane-bedded, sort sorted sand beds and pebble-rich sand unit are notified. Some pebble-rich cross-bedded unit shows the upstream dipping forests. There are two kinds of geomorphology surface have developed.

DEM OF KURTI RIVER BASIN

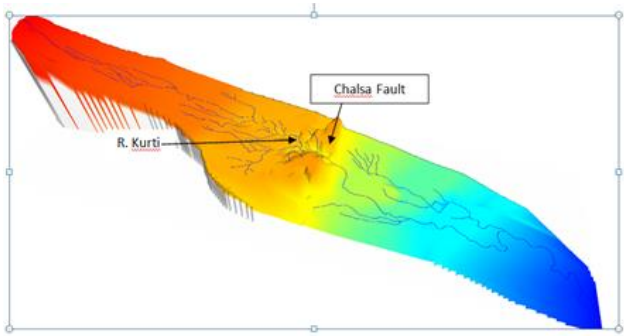


Fig. No.10 Showing the Digital Elevation Model with prominent view of Chalsa Scarp

A. River terrace-

Mainly two tire riverlines of unpaired - The middle part of the Kurti river i.e the Synformal axis zone is well characterized by the formation of river Terraces of unpaired in nature (Fig No.12.1). These formation is deformed by the two distinct cycle of erosion which occurred due to the tectonism and upliftment of the area.Thepoin of rejuvenation is identified in Metiali hat village where prominent break of slope is found along with incised meandering (Fig.No.11). Climatic terraces are also variable found in R. Chel where the river valley is going to be wider than the channel due to the piracy of channel water in the head ward areas by R. Mal near MBT .The structural control is the main dominating factor.The upper part of R. Mal near Mal Nadi Tea Garden this unpaired two tire terraces are found.(Fig No.12).These terraces are some where overlapped by the piedmont deposits, but well and distinctly they are the remnants of last tectonic movement.

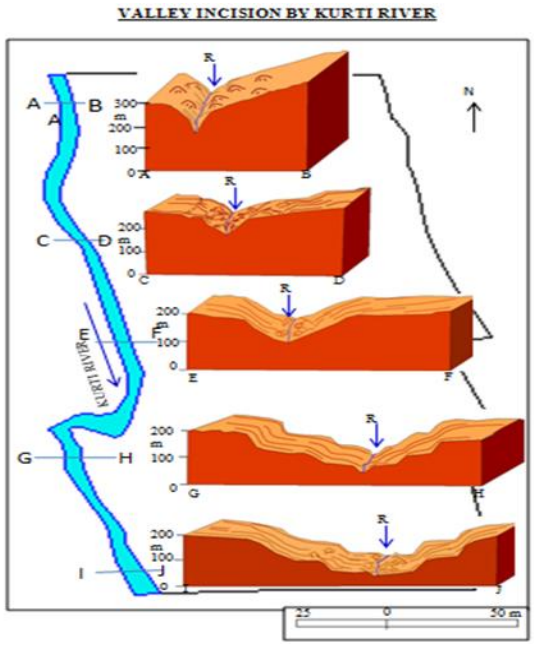


Fig. No.11 Showing the Terrace formation in R. Kurti

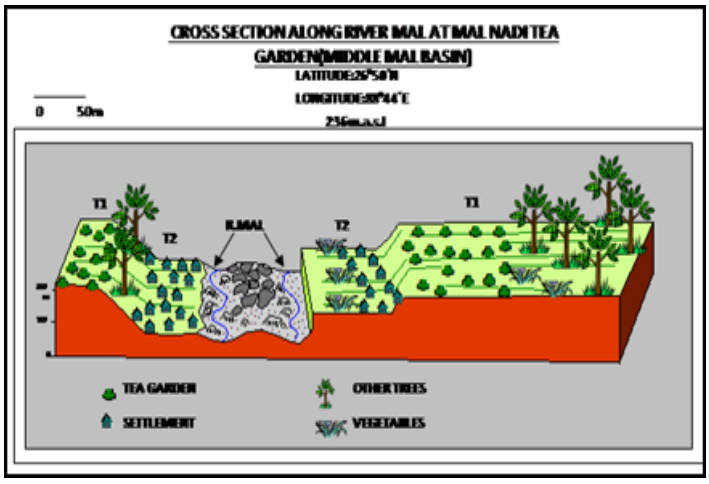


Fig No.12 Terrace formation in R. Mal

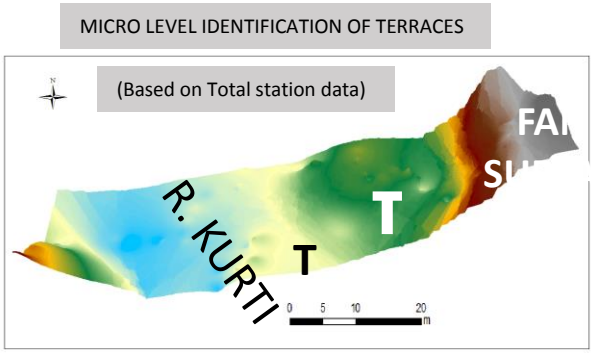


Fig No.12.1 Identification of Terraces in R. Kuri (Survey by Total Station)

B. Fan surface- (they are subdivided in three)

a. Samsing fan

b. Metiali fan

c. Chalsa fan

These geomorphology surfaces are mainly controlled by structure-evolution-drainage network etc.The detail study about the nature and development of alluvial fans is concerned with the morphological arrangements and mode of occurrences both in a quantitative as well as qualitative aspect with time and space .It is an ample scope for studying the evolution and developmental strategies of alluvial fans being originated by both endogenetic and exogenetic forces (Fig No.13). There are several macro and micro fans have developed over the entire elongated Himalayan foothills of West Bengal with spectacular land use development being influenced by slope, water velocity, carried materials etc.The mountain streams debouching out on a flat plain, deposits its load, building up an alluvial fan. The geometry of fans are mainly controlled by the relating factors like relief, climate, lithology and the hydrographic characteristics of the streams. The study area is composed of mainly Tista and Jaldhaka fan being over taken by many micro fans like Chel-Mal fan, Mal-Neora fan, Neora-Murtifan.etc. The alluvial fan deposits are coarse grained poorly sorted and immature sediments. Usually boulders and gravels predominate with subordinate amounts of sand, silt and sometime clay. The size of materials is large and process of soil formation is hampered by regular flood deposits. The development of fans arecontrolled by some integrated factors like- slope, climate, parent material, decrease of velocity etc. The piedmont zone of the foothills are well marked by the the effect of such wide and different features developed from Garubathan to Maynaguri area are found to be well manifested in the development of diverse land use in distinct geomorphic units of the study area.

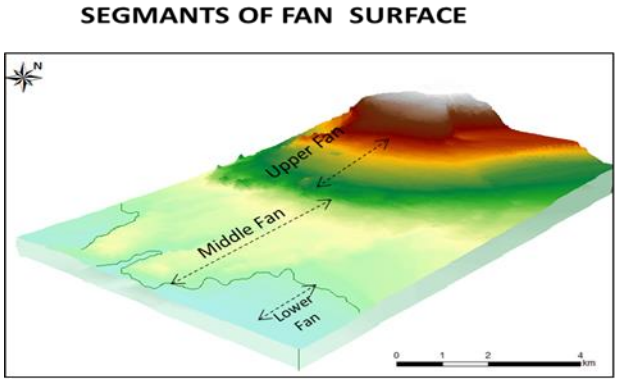
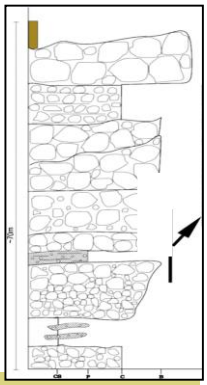


Fig No.13 Major Sub- divisions of Metiali fan

The large scale piedmont terraces with extensive flat alluvial fan deposits are formed by the result of progressive flattening of the gradient of the major rivers and their tributaries (Fig No.13). The study of Himalayan foothill region, reveals the manifestations of foreland-ward propagating components of the MFT within the Quaternary piedmont sediment. The successive northward-dipping Quaternary thrust faults delineated in the study area are the Gorubathan, Matiali and Chalsa thrusts. With the exception of the Gorubathan thrust, where unequivocal surface rupture is present, the Matiali and Chalsa faults are blind thrusts. The segmented and variable geometry of these thrusts imply that the MFT is still in its early stage of growth and the lateral linkages among active fault strands are yet to be established. The fine sand materials which must have been deposited downstream is *overlapped by the* younger fan deposits. The soils at the top of the fourth unit, when not eroded away, is observed as a reddish brown horizon and is made up of a small silt size traction. This unit has been named as Matiali formation after its type area at Matiali.



A log showing a coarsening upward succession of the Fan surface gravelly sediments.

Parallel stratified pebbly sand of sheet flood origin in the lower reaches of the Matiali fan

Southward dipping sandy gravel deposit near Chalsa scarp, west bank of the Kurti River.

Plate No.5. Identification of sediment layers of river Terraces

The middle fanarea ranges from boulder to sand size fractions. It has, in general a moderately deep but dull yellow colour which is pervasive throughout and the thickness in sections has been observed to be over 25 m at Chalsa and over 17m. near Noseatbari. The hydroxides and the black organic compounds at somewhat higher attitude where the third, fourth, and fifth units prevail .Thus soil layers ranges from a few cm. to 1m. and is generally thinner at the slopes. In the lower fan area. They are well developed black soil horizon overlying generally unoxidised weathering zone in next in order of antiquity. The sediments are mainly of coarse of fine sand grading southward, away from the foothills, to silt and clay. Where it has not been eroded away, a veneer of 4 cm. to 1m. thick dark, grayish black soil horizon containing organic matter is observed on the top of the deposit which is composed mainly of sand.

This foot hill zones of Quaternary deposits are mainly fluvial origin and fluvial terraces, alluvium fans and cones of recent origin are also abundant along the river section. They contain unoxidized sediments ranging from boulder to sand. Depositions are of broadly two phases, older one is of black soil cover. Both phases are benched at levels. The piedmont deposits have been grouped into 5 units from south to north based on the oxidation index, color of sediments (weathering zone) and the top soil (soil zone) (Chottopadhyay, Das, 1979).

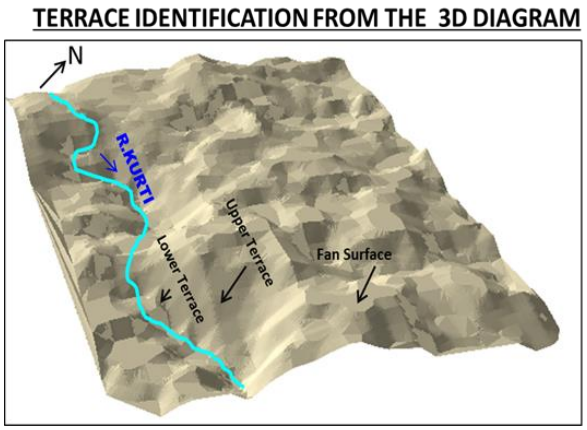
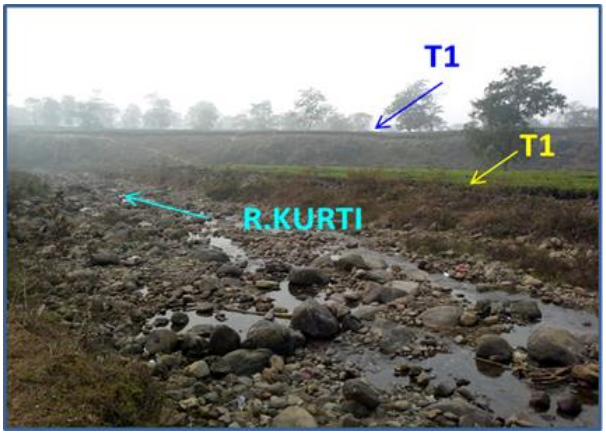


Fig No.13Micro level study of deformed landform by Total Station



PlateNo.5.1 Identification of river Terraces as deformed landforms

Plate No.6 Photographic Evidence of Metiali Scarp

VIII. CONCLUDING REMARKS

Our study of the Chel-Kurti Valley, Darjeeling–Sikkim Sub-Himalayan foothill region, reveals the manifestations of foreland-ward propagating components of the Neotectonic activity within the Quaternary piedmont sediment**.** A ramp anticline is formed on the fan surface and the sedimentary layers are also folded. The top part of the Matiali scarp is formed at this stage. The fan surface is uplifted on the northern side by about 20 m, as deduced from the height difference between T3 and Fan surface. The scarp disappears and the Fan surface extends continuously from north to south without a break. All the major rivers were antecedent to this movement. Incision kept pace with the uplift and the rivers cut through the growing anticlinal structure. No evidence of pending in the up thrown block can be found. After the cessation of the movement, the incised rivers widen their valleys and build up a new flood plain at a lower level more or less at the same level as the fan surface on the southern block. This is now represented by the T3 surface. The new sediments which formed the T3 surface were deposited unconformable on the folded and eroded older fan material that built up the Fan surface. Two stages of cycle of movement occurred on the area forming two unpaired terraces and finally the last stage of terrace formation gave rise to T1. The study reveals that the deposition and incision of the fan terrace system in this part of the eastern Himalaya was driven by climatic fluctuations; on-going tectonics is responsible for the development of fault-propagation folds involving the Quaternary deposits but did not directly influence the sedimentation of the fan–terrace system.

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AUTHOR'S PROFILE

Dr. Mery Biswas,is an Assistant Professor in the Department of Geography, Presidency University, India. Dr. Biswas is mainly included herself as a modern geomorphologist in applied context. Her research interests are concerned about the measurements and quantifications of fluvial landforms and its impact on different land uses regarding both time and space. The study bespeak about the structural evolution with the development of river networks on different landforms of an area where it is found to be develop an magnificent account of land use variability's. She is deeply concerned also about the identification of Micro geomorphological features and their process of formation.