INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Department of Geology and Geophysics

CHALSA FIELD REPORT 2024-2025

Group - 2

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ACKNOWLEDGMENT

We extend our heartfelt gratitude to the Department of Geology and Geophysics, IIT Kharagpur, for organizing this enriching field trip to Chalsa. This invaluable experience has greatly enhanced our understanding of geological processes and field methodologies.

We are deeply grateful to **Professor Saptarshi Dey** for meticulously planning and arranging the field trip and for his expert guidance throughout. His insightful explanations and encouragement significantly enriched our learning during the expedition.

Our sincere thanks also go to the dedicated Teaching Assistants, **Miss Sonali Das** and **Mr. Subhajit Mondal**, for their unwavering support and assistance throughout the trip. Their guidance and hard work were instrumental in ensuring the smooth execution of all activities.

We would also like to express our appreciation to everyone who contributed to making this field trip a highly inspiring and intellectually stimulating experience.

Lastly, we extend our gratitude to our batchmates and team members for their enthusiasm, teamwork, and support during the trip. Their cooperation and shared commitment made this journey both memorable and productive.

INTRODUCTION

The Chalsa region, located in the foothills of the Eastern Himalayas in West Bengal, serves as a unique geological laboratory for studying dynamic earth processes. The area's intricate interplay between tectonics, fluvial systems, and sedimentary environments provides critical insights into the ongoing geological evolution of the Himalayas. This report documents the findings of a seven-day field expedition conducted by Group 2 from the Department of Geology and Geophysics, IIT Kharagpur, under the guidance of Professor Saptarshi Dey. The fieldwork aimed to unravel the region's geomorphological, tectonic, and sedimentary processes through comprehensive observations, structural analyses, and sedimentological studies.

The primary focus of the fieldwork was to investigate the geological framework of the Chalsa region, particularly the interactions between significant tectonic features such as the Main Boundary Thrust (MBT), Main Central Thrust (MCT), and associated fault systems. These structures delineate key divisions within the Himalayas, influencing sediment transport, deformation, and landscape evolution. Additionally, the study explored terrace stratigraphy, paleochannel activity, metamorphic transitions, and depositional systems. These investigations provide a window into the historical and contemporary geological processes shaping the Himalayan foreland basin.

The methodology encompassed a range of techniques, including:

1. Clast Count Analysis: Identifying and quantifying rock types within fluvial deposits to trace their sources from the Higher and Lesser Himalayas.
2. Structural Mapping: Employing tools like clinometers, GPS devices, and stereonets to analyze faults, folds, and other tectonic features.
3. Sedimentological Logging: Recording sedimentary structures and textures to interpret depositional environments.
4. Paleochannel Reconstruction: Studying marker beds, imbricated clasts, and terrace stratigraphy to infer past fluvial activity.
5. Strain Analysis: Evaluating deformational features to deduce stress regimes and tectonic histories.

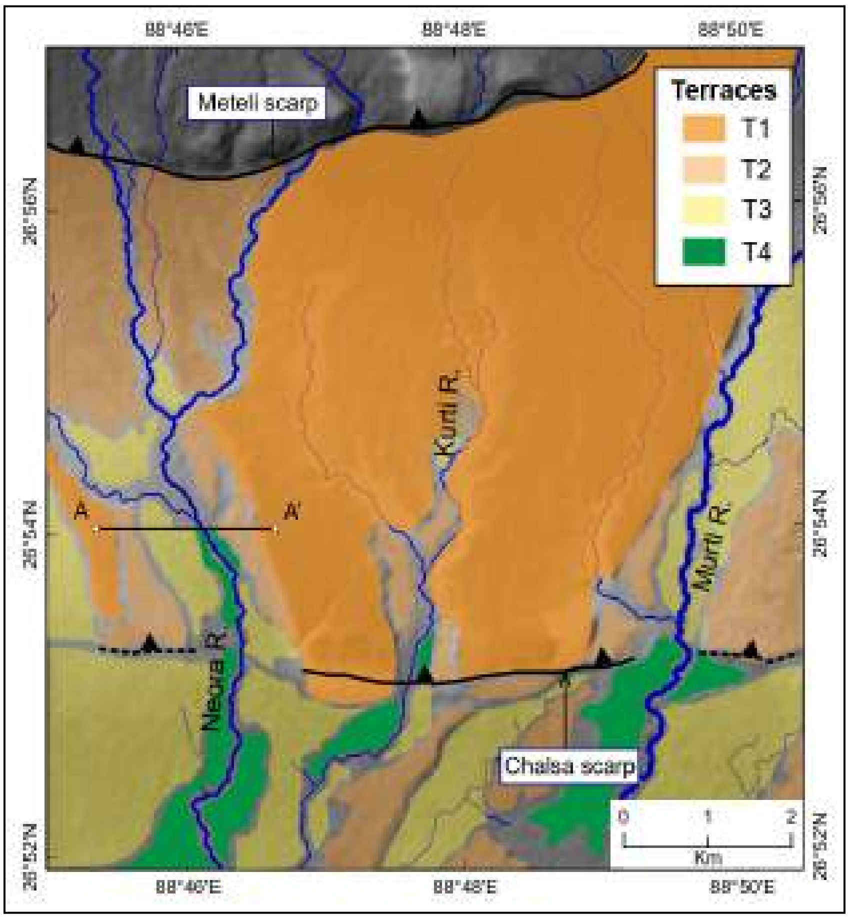
Through these approaches, the team investigated key sites such as the Murti River, Neora River, and the Jaldhaka tributary, each offering distinct insights into the region's geological complexity. For instance, clast composition along the Murti River revealed a dominant contribution from the Higher Himalayas, indicating greater erosion and sediment transport from these elevations. Similarly, observations at the Neora River highlighted terrace stratigraphy indicative of flash flood events, imbrication in sediment layers, and transitions in depositional regimes.

The findings also emphasize the geomorphic and tectonic significance of the region. The terraces and paleochannels reflect the interplay of hydrological and tectonic forces over millennia, while structural analyses reveal the active deformation shaping the Himalayan landscape. Observations of unconformities, knick points, and colluvial wedges underscore the dynamic interactions between uplift, erosion, and sedimentation. Additionally, studies of metamorphic features, such as garnet-bearing gneisses and sheared quartzites, provide a deeper understanding of the region's tectono-metamorphic history. This report aims to synthesize these diverse observations to present a coherent narrative of the geology of Chalsa region's.

OBJECTIVE

The primary objective of this fieldwork was to study and document the geomorphological and geological features of the Himalayan region near Chalsa, with a focus on understanding its dynamic processes and historical evolution. The study involved exploring significant structural and tectonic zones such as the Lesser Himalayas, Inner Himalayas, Main Central Thrust (MCT), and Main Boundary Thrust (MBT) to analyze their contributions to the regional geology.

A major focus was placed on analyzing geomorphological features, including terraces, gullies, and ancient river systems. Observations of sedimentary deposits and transported stones provided insights into the formation and evolution of these systems. Particular attention was given to studying the origins and characteristics of the Jaldhara River and the braided river systems prevalent in the region to understand their geomorphic processes.



The team also investigated tectonic activity by examining folds, faults, and sedimentary structures to assess their implications on regional dynamics. Anoxic layers associated with coal formation were studied in detail, along with crust counts and observations of metamorphic features, which revealed key aspects of the area's geological transformations.

In addition, sedimentary samples were collected for dating and further research to reconstruct the geological history of the region. This fieldwork aimed to provide a comprehensive understanding of the geomorphological, tectonic, and geological significance of the Himalayan landscape near Chalsa.

DAY-1

Location 1
26°49'36"N 88°49'40"E
Murti River

The Himalayan thrust system divides the mountain range into three distinct regions: the Higher Himalayas, the Lesser Himalayas, and the Sub-Himalayan region. The Main Central Thrust (MCT) serves as the boundary separating the Higher Himalayas from the Lesser Himalayas, while the Main Boundary Thrust (MBT) delineates the Lesser Himalayas from the Sub-Himalayan region.

Rivers flowing through these regions transport sediments that vary in composition, reflecting their geological origins. To analyze this sediment composition, a method known as clast counting is employed. This technique involves identifying and quantifying specific rock types within a defined area. In our study, we focused on a 3x3 meter plot to conduct the clast count.

Quartzite, a hard and resistant rock, is typically associated with the Lesser Himalayas and serves as a reliable indicator of this region. Conversely, gneissic rocks, which often contain garnet as an index mineral, are characteristic of the Higher Himalayas. By calculating the proportions of these index rocks through clast counting, we can derive insights into the relative contributions of sediments from both the Higher and Lesser Himalayas. This analysis not only enhances our understanding of sediment dynamics but also provides valuable information about the geological history of the Himalayan region.

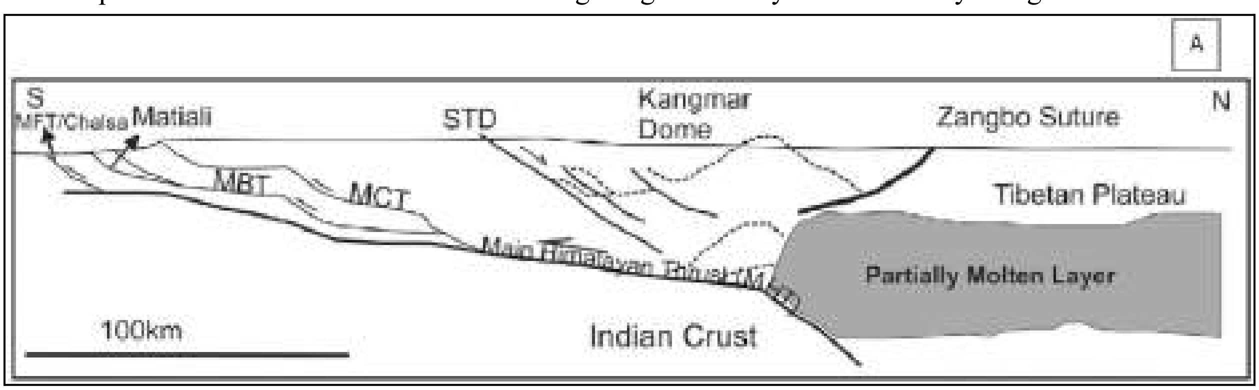
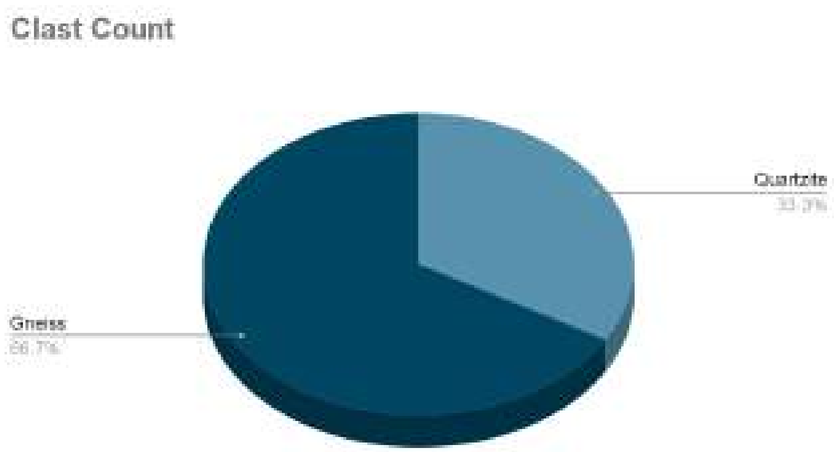


Fig. 1 Himalayan thrust system

Fig. 2 Study Area for Clast count near murti river

Observation



We observed that gneissic rocks were more abundant in the river valley. From this, we concluded that sediments from the Higher Himalayas have contributed more significantly to this area compared to those from the Lesser Himalayas. This could be attributed to the higher rate of erosion in the Higher Himalayas.

Additionally, we noticed that the rocks near the riverbed displayed imbrication. The imbrication is likely due to the heavier portions of the rocks dipping in the opposite direction to the river's flow.

Location 2
26°52'45"N 88°46'17"E
Neora river

The lower terrace sediments here exhibits flash flood the T1 logging shows that imbrication in the clasts in the sediment layers and the sediment layers are nearly horizontal.

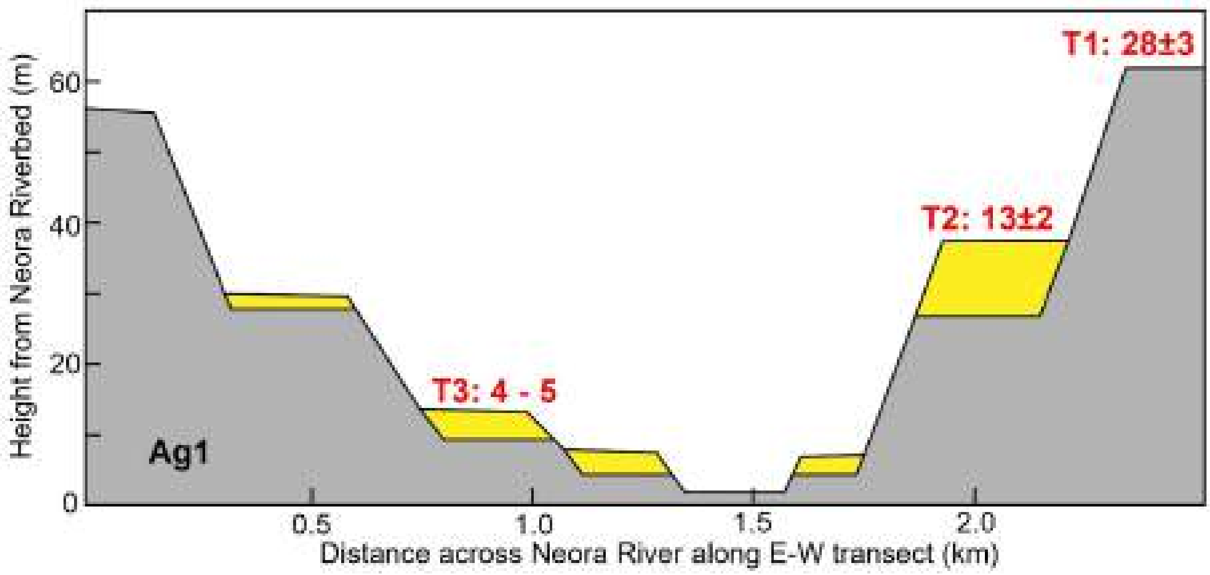


Fig 3. Terraces height and distance across neora river.

Fig 4. large 1m long boulder in the river bed deposited by flash floods

Fig 5 Imbrication of the small rocks in the river Neora.

Fig 6 T1 log showing Horizontal sediment layers and imbrications.

DAY-2

Location 1
26°53'29"N 88°43'10"E
Nadem Tea Estate
River Jaldhara Tributary

On Day 2, the fieldwork focused on the Nadem Tea Estate and the River Jaldhara tributary. Braided river The observations and exercises were as follows:

Measurement of Imbrications Azimuth

The azimuth of imbricated clasts was measured

Clast Shape Analysis

The ratio of the short axis to the long axis of clasts was measured to determine their degree of ellipticity or circularity. Observations were recorded to study changes in this ratio along the river, progressing upstream towards the north.

OBSERVATIONS

Sl.No	Rock type	Long axis	Short axis	Ratio	Azimuth
1	Gneiss	19	9	2.11	339.4
2	Gneiss	13.6	8.8	1.54	352.7
3	Gneiss	18.5	13.4	1.38	351.1
4	Gneiss	11.2	10.2	1.09	347.8
5	Gneiss	14.4	8.1	1.77	350
6	Gneiss	7.5	4.6	1.63	11.2
7	Gneiss	13.3	8.5	1.56	344.8
8	Gneiss	11.5	8.4	1.37	10
9	Gneiss	9.4	5	1.88	5.4
10	Quartzite	8.9	5.9	1.51	5.6
11	Gneiss	13.9	6.9	2.01	4
12	Quartzite	9.2	6	1.53	10.7
13	Gneiss	12.8	8.9	1.44	2.1
14	Gneiss	10.5	6.2	1.69	354.7
15	Quartzite	7.2	4.8	1.5	355.4

16	Gneiss	10.4	7.6	1.36	38.3
17	Gneiss	12.2	8.5	1.45	331.8
18	Quartzite	8.4	3.5	2.4	304.7
19	Gneiss	9	4.5	2	327.7
20	Gneiss	14.5	11.2	1.29	336.7
21	Gneiss	9.5	4.1	2.32	15.3
22	Gneiss	11.6	10.9	1.06	352.7
23	Quartzite	8.8	7.6	1.16	345.1
24	Gneiss	5.5	4	1.37	352.2
25	Gneiss	9.4	8.6	1.09	6.1
26	Gneiss	15.2	13.5	1.13	0.3
27	Gneiss	12	5.9	2.03	358.9
28	Quartzite	11.9	10.8	1.1	349.4
29	Gneiss	9.9	9	1.1	349.6
30	Gneiss	12.6	10.8	1.16	2.6
31	Gneiss	12.5	7.9	1.58	6
32	Gneiss	13.5	1.3	10.38	10.2
33	Gneiss	19	15	1.26	6
34	Gneiss	12	9.8	1.22	7.2
35	Gneiss	12.8	12	1.06	7
36	Quartzite	7.2	7	1.02	351.5
37	Gneiss	11.4	10	1.14	353.1
38	Gneiss	12	9.2	1.30	356.2
39	Gneiss	9.5	7	1.36	15.7
40	Gneiss	14.4	10.4	1.38	355.2
41	Gneiss	27	16	1.69	3
42	Quartzite	14.5	10.9	1.33	4.2

Terrace Log 2

Fig. 7 Jaldhaka river tributary terrace 1 log with scale.

Result

On making the rose diagram of the azimuth we find the trend of the imbricates is along the north-south direction and the long axis of the clasts are aligned in that direction with the heavier side dipping toward the north. Studying the log of the Terrace one we can understand the Brided

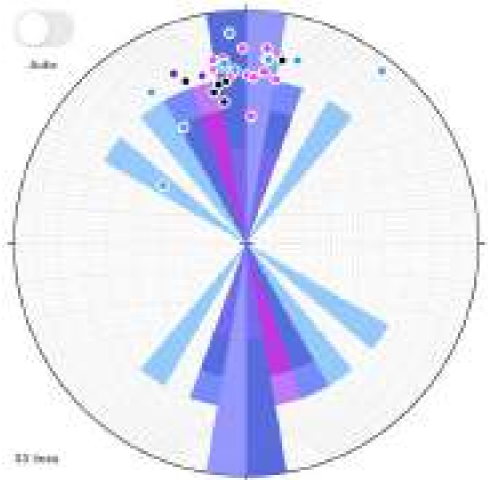


Fig 8 Rose diagram showing the trend of the azimuth of the imbricates

Location 2
26°52'57"N 88°42'52"E
Jaldhaka tributary

Fig 9

interfluve depositional

Terrace Section and Channel Structures

A terrace section was observed upstream, revealing channel and stream alignment towards the south. This was evidenced by a sand lens structure with pebbles displaying cross-bedding.

Anoxic black layers (marker beds) dipping towards the south were identified. These serve as indicators of paleochannel activity and depositional changes.

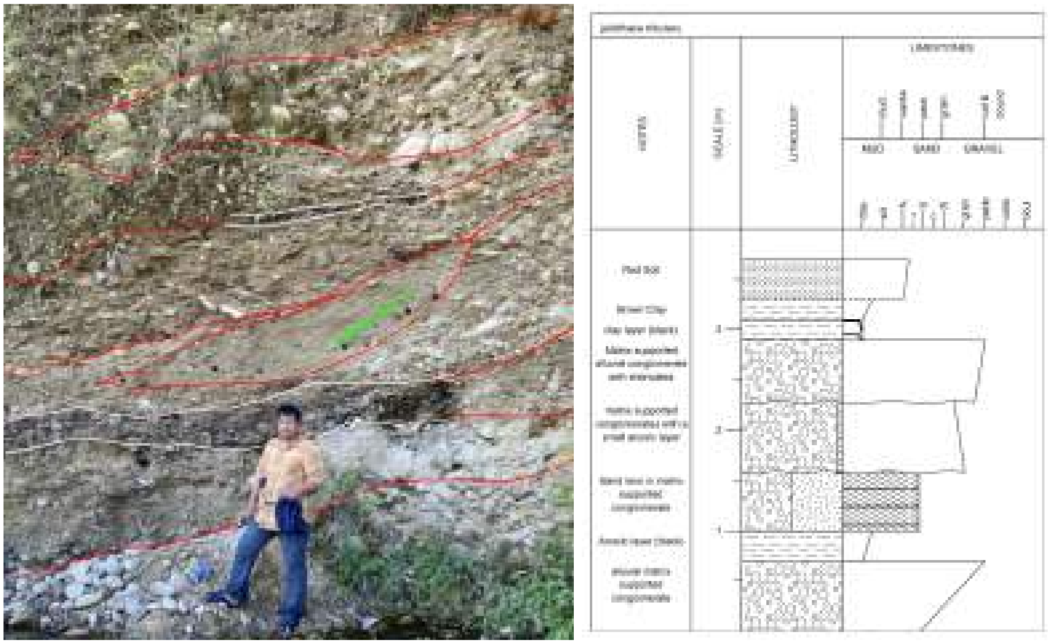


Fig. 10

Soil Formation and Depositional Environment
Soil formation was attributed to the breakdown of iron-rich mafic rocks from the higher Himalayas.
Black clayey layers indicating swampy conditions during deposition.
Brown clay layers marking a subsequent depositional phase.

The section transitioned from coarse-grained deposits at the base to finer-grained deposits at the top, reflecting a waning depositional system. The environment evolved from alluvial fan deposits to fluvial, lacustrine, and slow river flow systems.

Fig 11 impact shattering

Location 3
Neora river under Railway bridge
26°53'04"N 88°46'28"E

Fig. 12 valley incision

we can see coupled effect of anticline and the river incising through to make a very steep cut in the fig 12.

Paleochannel and Valley Formation

A paleochannel was identified based on visible sand deposits. At a location near the narrow train bridge, a valley formed by river incision and folding of the anticline limb was observed. This area marked the transition from a braided river system to a single-channel flow, with bedding dips and fault structures visible in the outcrop.

Unconformity and Fault Features

Fig. 13 unconformity

Fig. 14 fault

Unconformity

The boundary between Holocene horizontal beds and older faulted layers was observed. a Fine sand and suspected gouge material were identified in the faulted zone.

DAY-3

Location 1
26°53'17"N 88°46'14"E
Neora River paleochannels

Fig 15 paleochannel of neora river

Fanglomerate and Alluvial Clasts

Conglomerate Characteristics
Conglomerate clasts were observed, indicative of fluvial processes with debris flow characteristics. Pointer clasts suggested a medium-energy depositional environment.

1. **Depositional Environment**

Lacustrine Features:
Fine-grained sediment resembling clay was identified but confirmed as silt by tactile observation. Deposition occurred in a basin disconnected from active river flow, likely representing overbank deposits.
Seasonal Variations:
Brown Layers: Formed during summer monsoons due to increased surface runoff, resulting in thicker deposits. **Black Layers**: Formed in winter under reduced water conditions, representing organic-rich deposits. These layers were thinner and laminated. Seasonal alternation between flow and non-flow regimes was evident, with finer silt layers taking longer to deposit.

2. **Clast and Matrix Content** A higher matrix content was noted in some sections, while others contained more pebbles. Cross-bedding was visible, confirming the absence of clay and the dominance of silt in the deposits.

Location 2:
Quartz Clasts and Dropstones

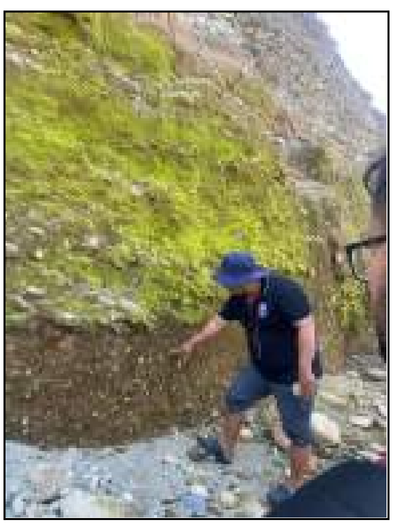


Fig. 16


Fig. 17 dropstone (Quartz Clasts)

Laminated layers contained clasts of quartz, possibly representing dropstones deposited from a higher energy regime.
Muscovite content was observed to be low, as confirmed by XRF analysis.

Fig. 18 Peat with visible petrified wood

Fig. 19 Lacustrine Black Clay deposits

Fig 20 muscovite inside the peat

The Himalayan river systems are profoundly shaped by incision processes driven by stream power, which refers to the energy available for river erosion and sediment transport. In this context, narrower river channels are observed to exhibit higher stream power, resulting in greater potential for incision into the landscape. This relationship highlights the dynamic interactions between hydrological forces and geological formations in the region.

Incision Law

The relationship governing erosion and incision can be encapsulated in a mathematical formula:

Erosion Incision=kAmSn

where *k* represents the erodability constant, A is the catchment area, and *S* denotes slope. The empirical constants m and *n* are positive values that further define the relationship. In this model, driving forces such as discharge and slope facilitate erosion, while sediment load serves as a resisting force against these processes

Fluvial System Balance

Lanes' Balance provides a conceptual framework for understanding equilibrium in fluvial systems. This model illustrates how sediment flux and grain size counterbalance stream power, creating a dynamic equilibrium. The tool and cover effects are critical in this balance; when sediment deposition rates are low, sediment acts as a tool for incision. Conversely, increased sediment availability can lead to aggradation, forming a cover effect that inhibits further incision. Notably, this relationship is size-dependent, with larger sediment particles contributing more significantly to aggradation.

Glacial and Rainfall Influence

The dynamics of glacial activity and seasonal rainfall significantly influence sediment supply and stream incision patterns within the Himalayan region. Glacial lake outburst floods (GLOFs) play a crucial role in mobilizing sediments and boulders that contribute to river incision. Research indicates that rivers with glaciated headwaters tend to maintain narrow valleys with exposed bedrock due to efficient erosional regimes driven by GLOFs. In contrast, tributaries in less frequently affected areas tend to be more alluviated, leading to stalled incision processes.
Seasonal rainfall variations also impact sediment transport and deposition, further complicating the interplay between hydrology and geomorphology in these river systems. The availability of sediment

directly influences the capacity for incision within fluvial systems, as depicted in graphical representations of tool and cover dynamics

Location 3
26°53'24"N 88°46'19"E
Gully (Neora river)

Fig. 21 Neora River terrace 2 logging

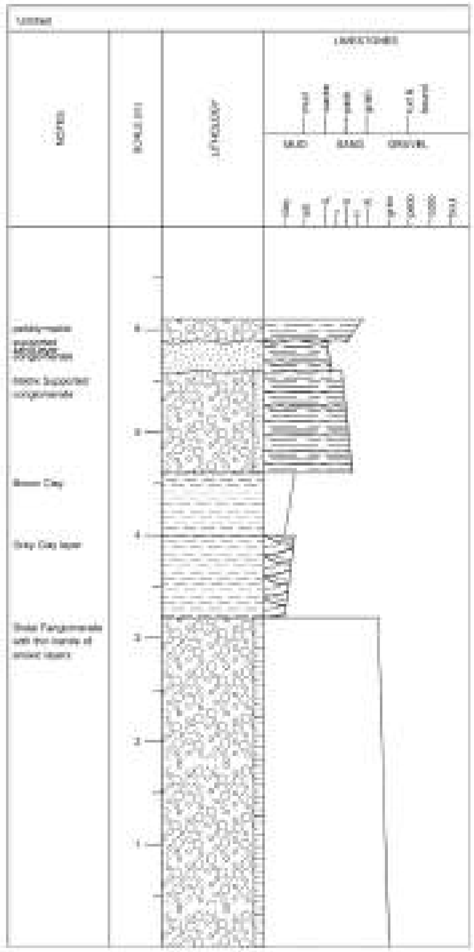


Fig. 22 log 4

DAY-4

Location 1
27°02'48"N 88°52'30"E
Metalli Fault and Chalsa Fault

Fig. 23 Fault splay of the Main boundary thrust (colluvial wedge is also visible) dipping towards SE.

Tectonic uplift and sedimentation are closely interconnected processes that shape the Earth's landscape, particularly in regions experiencing active tectonic activity. One notable phenomenon associated with this interaction is tectonic backfilling, which refers to the downstream uplift that occurs alongside the deposition of fine-grained sediments. This process highlights the dynamic relationship between tectonic forces and sedimentary processes.

Evidence of Active Tectonic and Sedimentary Processes

In a recent observation, a deep gorge was identified, indicating ongoing tectonic and sedimentary activity in the area. The presence of syn-sedimentary deformation was particularly noteworthy, as it demonstrated how sediment deposition can occur concurrently with tectonic movements. This deformation is characterized by the formation of colluvial wedges, which arise from the collapse of the hanging wall in a reverse fault system. Such wedges are indicative of active sedimentary basins where tectonic uplift contributes to sediment accumulation.

Fault Dynamics and Colluvial Wedge Formation

Within this context, small-scale faults exhibiting centimeter-level slips were identified. These faults play a significant role in shaping the landscape by influencing sediment distribution and deposition patterns. The collapse of the hanging wall associated with these faults results in the deposition of colluvial wedges, which are characteristic features of active sedimentary environments. Notably, the fault located above these formations remained unaffected, confirming that the observed syn-sedimentary deformation occurred without subsequent faulting.

Fig. 24 Jaldhaka River

Location 2
27°01'34"N 88°52'14"E
Sedimentary Dynamics and Terraces

The interplay between sediment flux and storage is a critical aspect of understanding sedimentary processes in river systems, particularly in regions characterized by significant geological activity. Recent studies have indicated that the total annual sediment flux from various geological formations, including folds and basins, to marine environments exceeds 1,000 million tonnes. This substantial movement of sediment underscores the dynamic nature of sediment transport and deposition in these areas.

Sedimentation in the Jaldhaka River

One noteworthy example is the Jaldhaka River, which, despite its relatively small size compared to other rivers in the region, has demonstrated considerable sedimentation capabilities. Observations revealed four distinct terrace levels along its banks, indicating a history of episodic sediment deposition. The complete absence of visible bedrock in the area further emphasizes the dominance of sediments, suggesting high levels of sediment storage and active incision processes. This phenomenon illustrates how even smaller rivers can play a significant role in shaping the landscape through sediment accumulation.

Paleo-Floodplain and Terrace Stratigraphy

The formation of terraces along the Jaldhaka River is closely linked to paleo-floodplain activities. These terraces serve as evidence of episodic sediment deposition that occurred during periods of fluctuating water levels. The stratigraphic record of these terraces provides insights into past environmental conditions and sediment dynamics, revealing how ancient floodplains influenced current sedimentary patterns.

Location 3
27°4'40"N 88°52'6"E
Gorubathan

Fig. 25 Main boundary thrust

Table 1 Measurements of MBT at Gorubathan

sl. No	Strike	Dip	Dip direction
1	**269.9**	**45.4**	**NW**
2	**244.9**	**45.2**	**NW**
3	**255.8**	**38.0**	**NW**
4	**252.8**	**46.5**	**NW**

The study of shear zones and metamorphic features in the Himalayan region provides crucial insights into the tectonic processes that shape this complex geological landscape. Observations made on the splays of the Main Boundary Thrust (MBT) revealed the presence of low-grade schists and quartzites, indicative of ductile deformation transitioning into brittle zones. This transition is significant as it highlights the varying degrees of deformation experienced along fault lines, particularly in areas where shear stress is prevalent.

Fig. 26 chevron fold

Shear Zones and Fault Activity

The identification of sheared gneiss and quartzite exhibiting sinistral shearing along the MBT underscores the active deformation occurring in this region. The formation of shear bands, characterized by quartz with melt intrusion and micaceous intergrowths, represents a form of ductile flow that occurs under high-stress conditions. These features are critical for understanding the mechanics of fault activity and the resulting metamorphic alterations in surrounding rock formations.

Metamorphic Grade Variation

A notable aspect of this research is the observed variation in metamorphic grades from south to north across the region. This gradient transitions from low-grade schists in the southern areas to garnet-bearing rocks found in the Higher Himalayas. The presence of sheared quartzites with chevron mica intergrowths further illustrates this metamorphic progression, particularly in shear zones associated with the Main Central Thrust (MCT). Such variations provide valuable information regarding the thermal and pressure conditions experienced by these rocks during their geological history.

Fig. 27

Table 2 Measurements of MCT at Gorubathan Road

Slno.	*strike*	*Dip Amount*	*Dip Direction*
1	*291.5*	*51*	*NW*
2	*281.1*	*55*	*NW*
3	*215.7*	*55*	*Nw*

Fault Angles and Tectonic Uplift

Measurements taken during field observations indicate specific fault angles, which are essential for understanding tectonic uplift dynamics. The MBT exhibits an angle of approximately 45°, while the MCT has a steeper angle of about 55°. Additionally, frontal fold ramps were measured at around 25°. These angles reflect the complex interplay between tectonic forces and climatic influences that contribute to uplift processes in the region.

Fig. 28 fish eye quartz

Petrographic Observations

Petrographic analyses revealed a variety of minerals, including fluorite, sericite, and quartz-bearing mica schists. The maximum temperature values (T-max) were considered for estimating metamorphic temperatures, further enhancing our understanding of the thermal history of these rocks. Such detailed petrographic observations are crucial for reconstructing past geological environments and understanding how they have evolved over time.

Geological Significance

The Himalayan region exemplifies active tectonics characterized by high sediment flux, terrace formation, and varying metamorphic gradients. These features provide key insights into Himalayan orogenesis and sedimentary processes. The study of shear zones, particularly their geometry, kinematics, and timing, is essential for understanding the broader tectonic evolution of this mountainous region.

DAY-5

Location 1:

Terrace Levels and Depositional Features

The study of terrace stratigraphy in the Himalayan region reveals significant insights into the depositional and erosional processes that have shaped the landscape over time. Recent observations focused on Terrace 4 (T4) and Terrace 3 (T3), highlighting their distinct characteristics and the geological events that influenced their formation.

Fig 29

Depositional and Erosional Characteristics

Terrace 3 exhibited clear evidence of flash flood remnants, indicating that high-energy depositional events occurred in the past. These remnants serve as a testament to the dynamic hydrological conditions that have influenced sediment transport and deposition in the region. The presence of such features suggests that T3 has experienced significant sedimentation during periods of intense rainfall or glacial melt, which are common in the Himalayan environment

Fig 30

Knick Point Formation

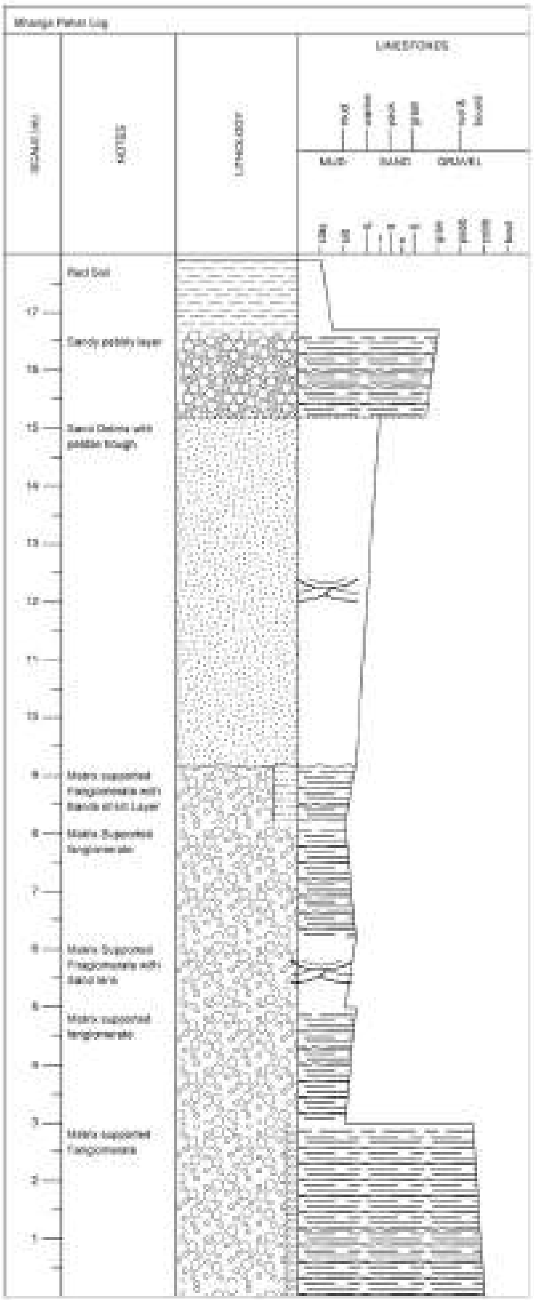
A prominent knick point was identified at the boundary where soft sediments meet harder strata. This knick point is actively incising into a yellow clay layer, creating a sharp erosional surface that further illustrates the ongoing geological processes at play. The sharp gap unconformity observed at this location consists of two distinct contacts separated by both time and sedimentary environment. The older contact, dating to the Late Pleistocene (approximately 25,000 to 60,000 years ago), is associated with piedmont fan deposits. In contrast, the younger contact represents Holocene sediments deposited under fluvial conditions, showcasing the transition from ancient to more recent geological activity.

Location 2:
Piedmont Fan and Bhanga Pahar

The geological features of the Piedmont Fan and Bhanga Pahar area provide significant insights into the sedimentary processes and environmental conditions that have shaped this region. The study of these features reveals a complex interplay of depositional and erosional dynamics, highlighting the impact of both tectonic activity and climatic influences.

Piedmont Fan Deposits

The piedmont fan deposits are characterized by a series of coarse sediments that have been laid down during episodic deposition events. Observations indicate a layered sequence transitioning from proximal to distal fan facies, which reflects a gradual decrease in energy as one moves away from the source of sediment. This stratification is typical of alluvial fans, where sediments are deposited in a conical shape as water flows out from confined channels onto broader plains. The coarse materials found in these deposits suggest high-energy conditions during their formation, likely associated with flash floods or rapid runoff events.



Bhanga Pahar

In the vicinity of Bhanga Pahar, classic fan morphology is evident, with clear signs of erosion and re-deposition processes. The stratigraphy in this area includes coarse materials interbedded with finer sediments, indicating alternating high-energy and low-energy depositional regimes. This variability in sediment size and composition reflects changing hydrological conditions over time, which can be attributed to fluctuations in climate or tectonic activity.

Fig 31

Organic Deposits

Within the stratigraphy, peat layers have been identified, suggesting the presence of localized swampy conditions during periods of reduced fluvial activity. These organic deposits are significant as they provide evidence of past environmental conditions that allowed for the accumulation of organic matter, further enriching the geological record of the area.

Fig. 32

Geological Significance

The interactions between tectonic and sedimentary processes are underscored by the sharp unconformity and knick point observed in the region. These features indicate significant tectonic activity that has influenced sediment deposition and incision over time. The transition from Late Pleistocene piedmont fans to Holocene fluvial sediments highlights the evolving depositional environment driven by climatic changes and tectonic forces.

Furthermore, evidence of flash flood remnants on Terrace 3 (T3) and the presence of knick points suggest episodic high-discharge events capable of reshaping the landscape. Such hydrological impacts are critical for understanding how extreme weather events can influence sediment dynamics and landform development in this region.

Conclusion
Day 5 provided detailed insights into the interaction of tectonics, sedimentation, and hydrology in the region. Key observations included terrace stratigraphy, unconformities, piedmont fan deposits, and organic layers, which together enhance the understanding of past depositional and erosional processes.

DAY-6

Location 1:

The geological features of the Lesser Himalayas provide significant insights into the processes of sedimentation and tectonic activity in the region. The dominant bedrock consists primarily of muscovite schist and quartzite, which are characteristic of the metamorphic rocks found in this area. Observations of pressure shadows around biotite grains indicate past deformation, highlighting the influence of stress fields on these rocks. This region is situated along the Main Boundary Thrust (MBT), a critical tectonic boundary that separates the Lesser Himalayas from the Siwalik range.

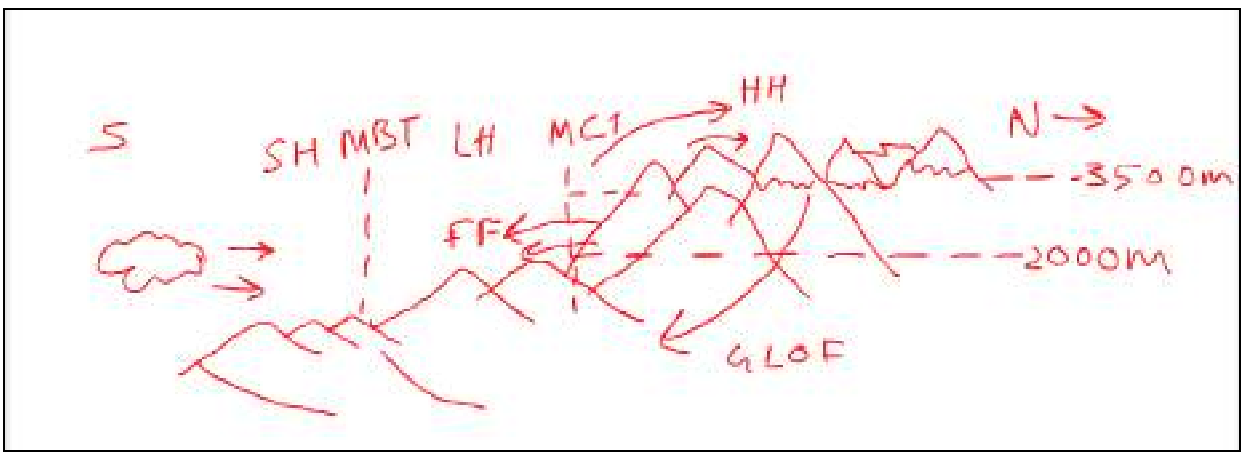


Fig. 33

Sedimentary Features and Flash Flood Evidence

In addition to bedrock observations, sedimentary features in the area reveal a history of significant sediment deposition. Notably, super coarse sediments containing boulders as large as two meters were identified, suggesting intense fluvial activity. The polishing of these boulders indicates that they have been shaped by powerful water flows, likely resulting from flash floods during monsoonal events or glacial melt from higher elevations. These coarse sediment deposits provide crucial evidence of the hydrological processes that have shaped the landscape.

Fig 34

Fig 35

Source of Sediments

The sedimentary deposits in this region include garnet-bearing gneiss, quartz, and biotite, pointing to their origins in the Higher Himalayas. In contrast, contributions from the Lesser Himalayas are relatively minimal due to their lower elevation. This disparity highlights the significant role that higher elevations play in sediment production and transport, particularly during periods of increased hydrological activity.

Hydrological Processes

Current observations indicate that while the present river flow is relatively subdued, the sediment record suggests that high-energy events have occurred periodically in the past. These events may have been driven by extreme weather phenomena such as cloud bursts or glacial lake outbursts, which can lead to sudden and intense flooding. The evidence of past high-energy flows is essential for understanding both the historical and contemporary hydrological dynamics in this mountainous region.

Location 2:
Low-Grade Metasedimentary Rocks

Rock Types and Structures

The geological landscape of the Lesser Himalayas is predominantly characterized by low-grade metamorphic rocks, including quartzite and quartz-bearing mica schist. These rock types exhibit high strength, which is a defining feature of the bedrock in this region. The structural characteristics of these rocks provide valuable insights into the tectonic processes that have shaped the Himalayas over geological time.

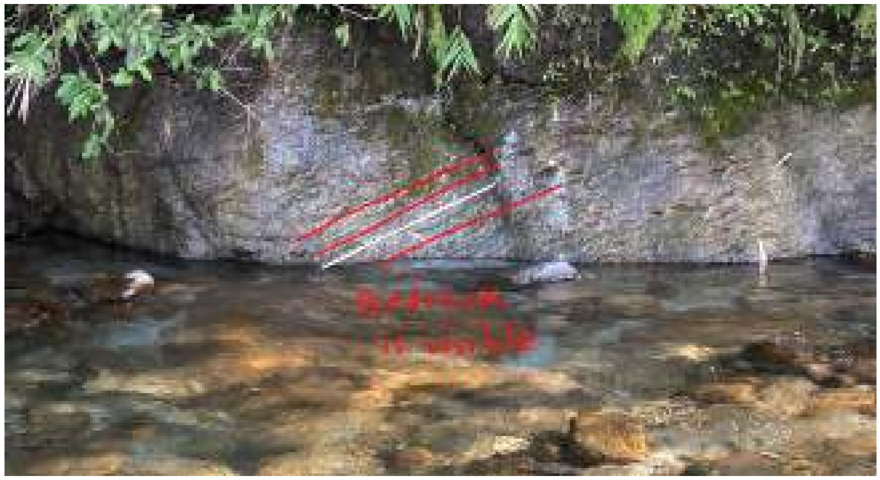


Fig 36 Bedrock Schist inclined beds

Structural Features

Among the notable structural features observed in the Lesser Himalayas are boudins found in hinge zones, which indicate ductile deformation. This phenomenon occurs when rock layers are stretched and subsequently break into segments, reflecting the intense tectonic forces at play. Additionally, evidence of fault propagation folding has been documented, where folding occurs in conjunction with the growth of fault zones. This simultaneous development highlights the complex interactions between folding and faulting as tectonic forces reshape the landscape.

Fig 37 Isoclinal Folding (phylite)

Fig 38 Joint planes acute bisector given sigma 1(green)

Table 3 Measurements of the Two Joint planes At location lat26.9809353 long 88.70004587

Joint Planes	*Stike*	*Dip amount*	*Dip Direction*
1	*276.4*	*23*	*NW*
2	*249.7*	*42.8*	*NW*

Fig 39 Folded band of Quartzite

The analysis of joint planes here within these rocks gives that the maximum principal stress (σ1) acts as the acute bisector of two joint planes. This relationship is crucial for understanding how stress is distributed within rock formations and how it influences their structural integrity.

Location 5
27°00'43"N 88°41'59"E
Ramgarh Thrust

The **Ramgarh Thrust** is a significant geological feature within the Lesser Himalayas, serving as a boundary that separates quartzite-dominated bedrock from schist-dominated formations. This thrust is characterized by various structural and sedimentary features that offer insights into the tectonic processes at play in the region.

Geological Observations

Recent observations along the Ramgarh Thrust have revealed evidence of small faults and associated milled rocks, which indicate active tectonic movement. Additionally, layers of phyllite exhibiting thrust motion further illustrate the dynamic nature of this geological boundary. The presence of isoclinal folds within some rock layers demonstrates the intense compressional forces that have shaped the landscape, indicative of significant tectonic stress.

Fig. 40

Tectonic Context

The Ramgarh Thrust is influenced by the broader tectonics associated with the Main Boundary Thrust (MBT). Observations indicate that joint orientations in the area align with regional stress fields, providing further evidence of the complex interplay between tectonic forces and rock deformation. This alignment is crucial for understanding how stress is distributed across various geological formations in the Lesser Himalayas.

Fig 41

Geological Significance

Sedimentary and Tectonic Interplay

1. The super coarse sediments reflect extreme depositional events linked to climate-driven floods or tectonic uplift.
2. The presence of high-grade Himalayan gneiss and garnet indicates sediment transport from higher elevations.

Structural Insights

1. Fault propagation folding and boudinage reflect the ductile deformation processes occurring in deeper crustal levels.
2. The Ramgarh Thrust and associated features provide evidence of active tectonic adjustments in the Lesser Himalayas.

Conclusion

Day 6 highlighted the intricate relationships between tectonic activity, sediment transport, and depositional environments. The observations of large boulder deposits, schist bedrock, and structural features like isoclinal folds and boudins provide valuable insights into the dynamic geological processes shaping the region.

DAY-7

Location 1
26°52'58"N 88°47'32"E
Fault and Structural Observations

Fig 42

Fault Observations

Observations indicate that the matrix of the fault exhibits visible cracks in multiple directions, suggesting ongoing deformation within the rock structure. The fault itself is characterized by a vertical orientation and displays features typical of a rotated thrust fault, which are commonly found in Himalayan geology. This vertical alignment is indicative of the compressional forces at work in the region.

Evidence of Fold Rotation Through Crack Orientations

During our field observations, we identified rocks with cracks and fractures oriented in various directions. This variation in crack orientation serves as evidence of fold rotation, a process where the original geometry of a fold is altered due to tectonic forces. As the fold rotates, the stress direction acting on the rocks changes over time, causing new fractures to develop at angles different from the pre-existing ones. This phenomenon indicates a dynamic deformation history, suggesting progressive tectonic activity in the region. The varying orientations of the cracks highlight the complexity of the stress regime and provide insights into the kinematics of folding and faulting in the area.

Movements of Hanging Wall and Footwall

In line with typical faulting behavior, the hanging wall has moved upward while the footwall has shifted downward. This movement pattern is essential for understanding the mechanics of fault dynamics and illustrates how tectonic forces can lead to significant geological changes over time.

Antithetic Faults and Low-Angle Folding

Alongside the main fault, antithetic faults have been observed, indicating a complex faulting process that contributes to the overall structural evolution of the area. These smaller faults often form in response to the stress fields generated by larger faults, highlighting the interconnectedness of geological features. Additionally, low-angle folding associated with the fault structure suggests that the region has experienced significant compressional stress, further complicating its tectonic history.

Geometric Relationship Between Shortening, Uplift, and Slip

The relationship between shortening, uplift, and slip can be represented as a right-angled triangle, where the ratio of uplift to shortening equals the tangent of the angle ($\tan \theta$), and the ratio of uplift to slip equals the sine of the angle ($\sin \theta$).

Tectonic History and Movement

The tectonic history of this region is marked by notable slip events, including evidence of a mega earthquake that occurred approximately 1,100 years ago, resulting in substantial slip along the fault. Current estimates suggest a slip rate of around 8 mm per year, reflecting ongoing tectonic movement and activity in the area. This continuous movement underscores the dynamic nature of Himalayan geology and its susceptibility to seismic events.

Conclusion

Day 7 focused on, the observations of faults within this Himalayan region providing critical insights into its tectonic history and structural characteristics. The interplay between matrix cracking, hanging wall and footwall movements, antithetic faults, and low-angle folding illustrates a complex geological environment shaped by significant compressional forces. Understanding these dynamics is essential for comprehending not only local geological processes but also broader tectonic mechanisms that govern mountain formation and seismic activity in this seismically active region. As research continues to evolve, it will enhance our knowledge of how such geological features develop and interact over time.

Bibliography

1. Kumar et.al (2010)

2. Biswas, Mery & Paul, Ankita. (2020). Application of geomorphic indices to Address the foreland Himalayan tectonics and landform deformation- Matiali-Chalsa- Baradighi recess, West Bengal, India. Quaternary International. 585. 10.1016/j.quaint.2020.12.012.