A Geological Field Report on Sitapahar Anticline Structure, Rangamati, Chittagong, Bangladesh.

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Contents

Abstract

Field work is an essential part in the field of Geology for understanding geological features and components of the Earth. Every year students of 3rd year (Hon's) of Department of Geological Sciences, Jahangirnagar University conduct a field work at the Ghagra-Rangamati Road Cut section, Rangamati, Chittagong. Where we basically study the Sitapahar Anticline structure and its adjacent areas. Sitapahar Anticline is characterized by a series of parallel ranges of hills trending NNW-SSE. They are extensional expression of the Indo-Burma Folded belt of Bengal Foredeep formed by compressional forces during pliocene. It is an asymmetrical fold with steep western flank and gentle eastern flank.

The structure may be fault controlled which may be thrust fault indicate by abrupt change in dip amount, layer displacement and valley. Four major rock units:

Unit A- yellowish brown loosely compacted sandstone

Unit B- moderately compated yellowish brown sandstone

Unit C- sandyshale and

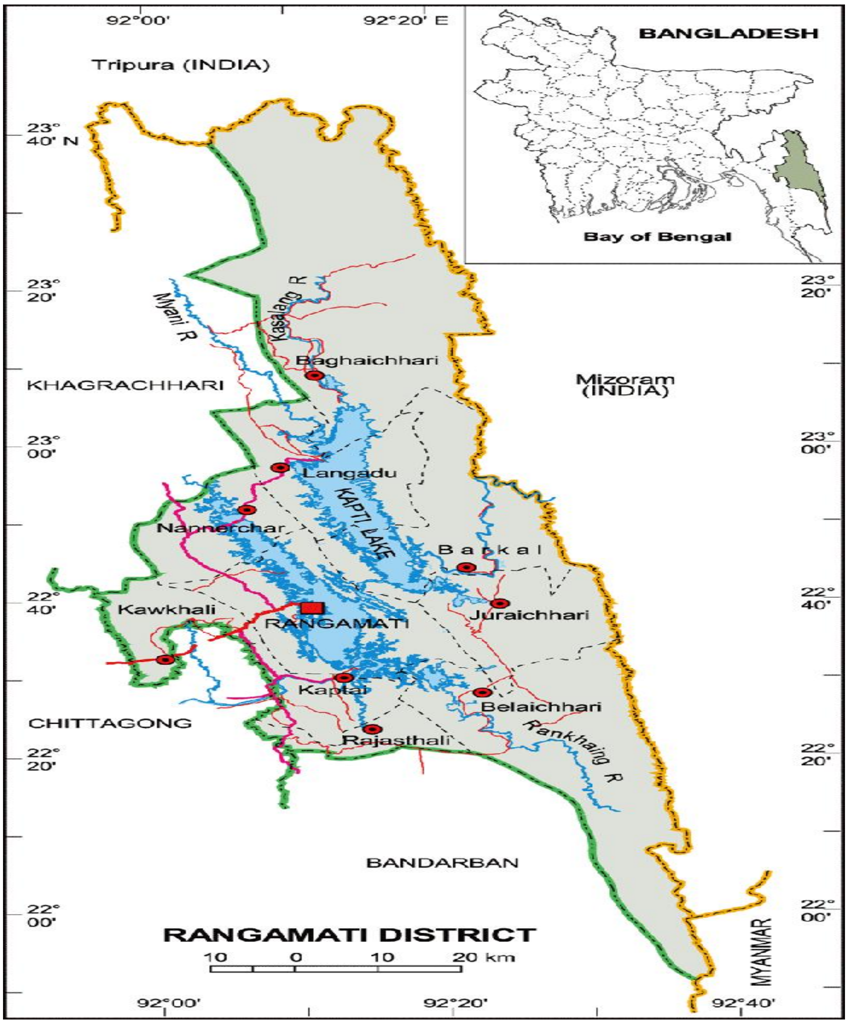
Unit D- nodular bluish gray shale

These rock units are correlated Dupitila formation, Tipam sandstone, Bokabil Formation and Bhuban formation respectively. The Study of lithology, sedimentary structure, grain size parameters and degree of sorting reveal that the sediments were deposited in shallow Marine to Fluvial environmental.

CHAPTER ONE: INTRODUCTION

Location and extent

The field work was done at Sitapahar Structure which is also known as Rangamati Structure, situated within the middle asymmetrical thrust faulted zone of the CTFB. The Sitapahar Structure lies between latitudes 22˚ 22′ 08″ N to 22˚ 40′ 13″ N and longitudes 90˚ 04′ 07″ E to 90˚15′20″ E. The structure is approximately 39 km long, about 7.5 km in width and comprises mostly hilly terrains. It covers an area of about 292 sq. km. The Sitapahar and its adjacent structures have similar structural trend and topographic height. The structures are cut by dendritic drainage network of small stream, streamlets and antecedent rivers.



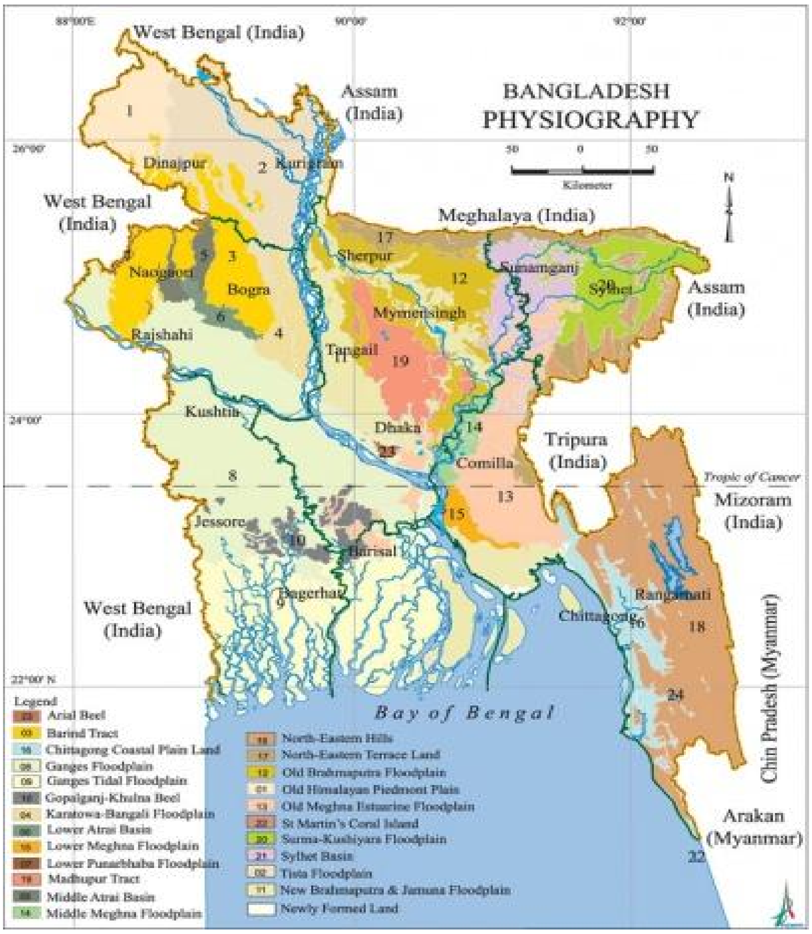
Map 1: Location map of Rangamati district (Banglapedia)

Accessibility

Rangamati is 337 kilometers from Dhaka and 77 kilometers from Chittagong. It is directly linked with major cities of Bangladesh by road, rail, and air. Kaptai reservoir against the river Karnaphuli literally encloses the Rangamati town as a whole, hence, the accessibility of the area is clearly easy.

Physiography

Rangamati is situated at the south eastern part of Bangladesh. The investigated area in Rangamati is hilly region with irregular topography, this area is characterized by a number of hill rocks, spurs, ridges. And valley. The structure is bordered on the east by the Belasari and Gilasari Structures; on the west by the Lambaghona and Patia Structures; on the north by the Changotaung structure; and on the south the structure is plunging and cut by antecedent Karnaphuli river. This region is highly designated by valley with parallel ridges, the ridges are parallel to the regional structure of Chittagong hill range trending NNW-SSE.



Map 2: Physiographic units of Bangladesh (Reimann,1993).

Riemann (1993) has subdivided Bangladesh into nine sub-division. According to this, the study area is situated in Chittagong hill tract. Numerous streams and streamlets are present in the Rangamati Hill Range. Locally, these streams are called charra. Length of these streams are ranging from few meters to kilometers. The streams within the area are mostly seasonal, intermittent and perennial in nature. In general, the drainage of Rangamati Hill Range is dendritic pattern. The area can be characterized by tropical to sub-tropical climatic condition.

Regional geology and Tectonics

The tectonic evolution of Rangamati structure is related with the tectonic evolution of the Bengal Basin. Bengal Basin has evolved through the late Paleozoic to recent times. It is a peripheral collisional foreland basin, which is located at the eastern part of the Indo-Gangetic plain. The basin is bounded by the Himalayan Foredeep, the Shillong Plateau and the Assam Basin in the north, the Indian Shield in the west and Indo-Burman Ranges to the east but in the south, it is extended to the Bay of Bengal. Bengal basin comprises Bangladesh, parts of the Indian states of West Bengal, Tripura and Assam. The Bengal Basin is developed through the interaction and collision between the Eurasian, the Indian and the Burmese Plates. It is one of the deepest sedimentary basins of the world, which is divided into three major Geo-tectonic provinces based on overall tectonic setting & sedimentation pattern-

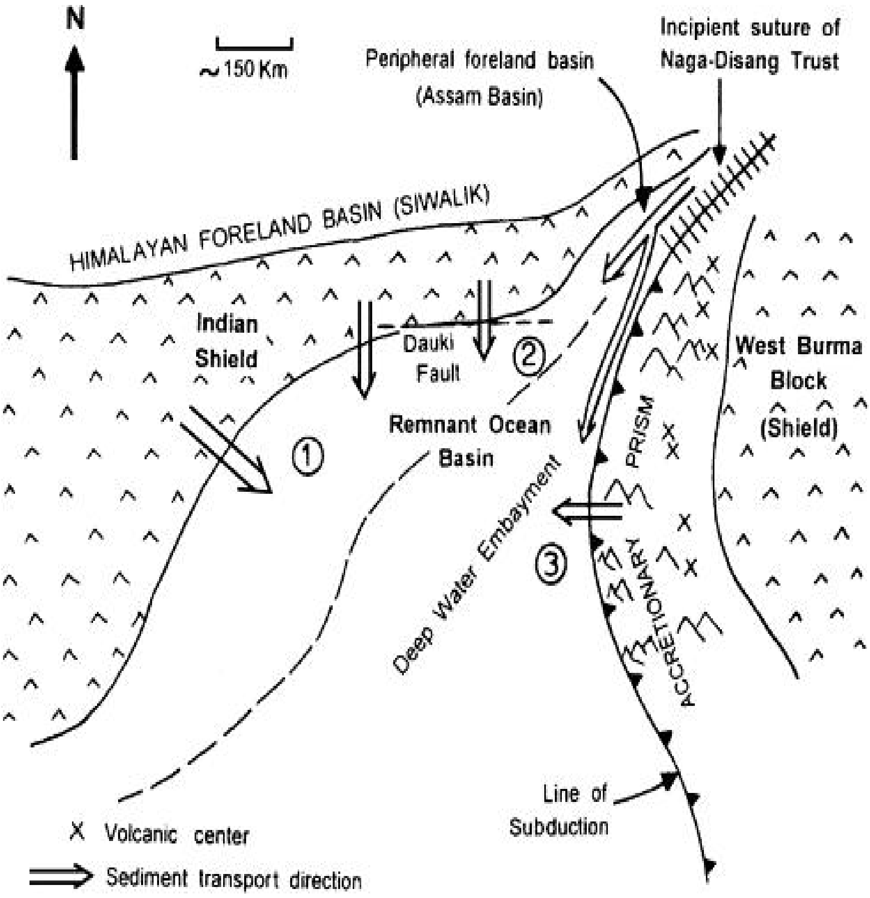
i)Geo-tectonic province 1- The Stable Shelf

ii) Geo-tectonic Province 2- The central deep foredeep basin

iii) Geo-tectonic province 3- The folded flank (CTFB)

The Bengal basin developed through two major tectonic events. The first event happened through the Late Paleozoic to Mid Mesozoic when the Bengal Basin originated as an intra-cratonic rift basin within the Gondwana Landmass. During this time the basin received continental Gondwana sediments. At the end of this event the Geo-tectonic province 1 of the Bengal basin faced widespread volcanism as a result of the Kerguelen igneous activity. The flood basalts formed from this volcanism known as Rajmahal trap which is covering the Gondwana sediments. During this time period, the Geo-tectonic Province 2 was influenced by marine environment and also got affected by this volcanic activity. The second event of basin evolution began in the Late Mesozoic with the break-up of the Gondwana and is still continuing. During the initial break-up of the Gondwana and the formation of the Indian Plate, the base of the Geo-tectonic Province 2 was developed as a transitional zone between continental & oceanic crust. The Geo-tectonic Province 2 subsequently subsided and received a massive volume of sediments from the Late Mesozoic through Tertiary till Recent times. Later, the oceanic part of the

Indian Plate collided with a Neo-Tethyan intra-oceanic arc during the Late Cretaceous-Paleocene because of its rapid northward's movement. With further movement, the continental part of the Indian Plate collided with the Tibetan part of the Eurasian Plate during the Eocene- Oligocene. As a result, the northern portion of the Indian plate subducted beneath the southern Tibet. This continental convergence resulted in folding and thrusting & caused the first upliftment in the Himalayan region. Further migration of the Indian Plate continued in the north-easterly direction, causing collision of the Indian Plate with the Burmese Plate and resulted initial uplift in the IBR region during the



Late Oligocene-Early Miocene. During this time, the Geo-tectonic Province 2 or the central Foredeep Basin also got separated from Assam Basin as a 'remnant ocean basin'. The Geo-tectonic Province 3-CTFB started to develop during the Late Pliocene. The structural development of CTFB is related with the upliftment of the IBR ranges whereas the stratigraphy of this province is vastly similar to those found along the southern sub-Himalayan Belt. CTFB comprises the eastern part of the Bengal Basin. It is subdivided into three zones: eastern highly compressed disturbed zone, middle asymmetric thrust faulted zone, and western quiet zone.

Map 3: Schematic Early Miocene paleogeographic representation of the Bengal Basin andsurrounding region in terms of the plate tectonic model. Positions of the three geo-tectonic provinces of the basin are shown by encircled numbers: (1) The Stable Shelf; (2) The CentralDeep Basin; and (3) The Chittagong–Tripura Fold Belt.

The study area falls within the middle asymmetric thrust faulted zone, which is in the west of the highly compressed zone.

Previous investigation

Many geologists surveyed the Sitapahar anticline in the south-eastern part of Bangladesh. Shell attempted to know about the sub-surface structural configuration with seismic surveys. They attempted to drill a deep exploration well on the Sitapahar anticline which was about 1377m in depth (in 1988). There are not many publications that presented facies analysis on these clastic rocks exposed in southern part of CTFB (Alam, 1995; Alam and Ferdous, 1995, 1996; Alam and Karim, 1997; Gani and Alam, 1999). The significance of tidal influence in shallow marine Surma Group was first discussed by Alam (1995).Gani and Alam (1999) have suggested that the entire Surma Group succession represents an overall basinward progradation from deep marine to coastal marine within the active margin setting of the Indo-Burmese plate convergence. Gani and Alam, latter in another publication (2000), have shown a detailed lithofacies analysis and gave an interpretation about the origin of, and genetic relationships between, individual units in response to sea-level changes.

Purpose and scope of investigation

Field study primarily means obtaining geologic knowledge. It employs method and techniques to examine the structure, physical features, stratigraphy and also materials exposed at the outcrop. The eastern and more importantly the southeastern part of Bangladesh is much complex and exhibits much of the tectonic evolution of the Bengal basin. The area consists one of the major tectonic elements of the Bengal basin i.e. The Frontal Fold belt. The rocks exposed here ranges from the age of Miocene to Pliocene. On the contrary the area has the drawback of lacking petroleum. Nonetheless the area is a paramount for geologic study. Huge piles of sediments are exposed to be studied and enhance the knowledge of the complexities of the nature. Our main purpose was to observe and study the structure, sedimentation history, stratigraphy, fossils, depositional environment, and economic geology of the area and also to make a geological map of the studied area.The purposes can be described briefly as –

- Preparation of a geological map of an area.

- Determination of lithology and sedimentary structures.
- Construction of stratigraphic column.
- Study of formation of the column.
- Study of sedimentary structures and other structural features.
- Interpretation of the geologic history of the area.
- Prediction of the economic importance of the area.

It is to be noted that, though the investigated area offered very good scope, to study properly the time schedule was very short, very detail investigations were not possible.

Methods and Equipment used in the field

The investigation was divided into two parts-

1. Investigation in the field
2. Laboratory analysis (sieving)

For geological field mapping, traverse method has been used. This technique involves measuring distance and identifying position in a map by measuring distance by pacing. Rock samples have been studied visually and observations have been written in field notebook. Then potted on the map according to their geographic locations. One of the key observations include identification of the sedimentary structures (if any) and understanding the significance of that structure in the context of depositional setting. Mapabble litho-stratigraphic units have been classified based on lithology (rock assemblages). Stratigraphic correlation among different section of the area has been done. In order to understand the structural geology of the area, structural measurement (dip and strike) have been taken and immediately plotted on the map. Geological cross-section has been constructed to understand the subsurface geology.

Finally, all the observations have been used to synthesize a coherent geological history of the area.

Samples of rock were collected for laboratory analysis from suitable formation/ exposures and properly labeled by sampling. The samples were collected into sample bags. Photographs were also taken of important geological features to submit with the report. We used different equipment's during our field work. They are as follows:

Table 1: Equipment's used in the field

Equipments	Uses

1.Base map	To locate the observed informations in the base map.
2.Clinometer	To find out the proper bed, attitude of the bed and sedimentary structure.
3.Pocket lens	To identify the grain size of the rocks.
4.Note book	Used to note down the data and other information.
5.Haversack	Used to carry all the equipment.
6.Hammer	Used to loosen and collect rocks samples.
7.Water bottle	Used to carry water to drink.
8.Dilute HCl (1m)	Used to test the nature of cementing material.
9.Sample bag, Tag & rubber band	To collect and indicate the representative sample for laboratory analysis.
10.Camera	Used to take photograph of geologic feature.
11.First aid box	To protect any initial infection.

CHAPTER TWO: SEDIMENTOLOGY

Lithofacies

Based on the analysis of color, texture, composition, and sedimentary structure of the rocks, two major lithofacies were identified on the Rangamati Hill range area and these are as follows:

1. Sandstone Facies
2. Shale Facies

Sandstone Facies

1. Massive Sandstone: Yellowish brown in color, medium to fine grained, loosely compacted, moderately sorted, highly porous, found Iron layer due to oxidation and leaching, Clay gall and clay layer were found. Small scale trough cross bedding, cross lamination and tabular cross bedding were also found.
2. Ripple Cross Laminated Sandstone: Gray color, very fine grained, ripples are assymetric in profiles and sinuous crested. This facies is predominant in the investigated area. This type of facies deposited in abandoned part of channel.
3. Moderately Compacted Sandstone: Yellowish brown in color, fine to very fine grain size, massive structure, highly permeable. It contains iron concretion, clay gall and burrows.
4. Trough Cross Bedded Sandstone: Gray in color.

Grain Size Analysis

Grain size analysis includes the mechanical analysis and mineralogical study of the sediments. The purpose of this work is to examine the exposed sediments and to determine their lithological characteristics. In laboratory we have worked on grain size analysis and heavy mineral separation and identification.

Grain size is a fundamental attribute of siliciclastic sedimentary rocks and thus one of the important descriptive properties of such rocks. Sedimentologists are particularly concerned with three aspects of particle size:

1. Techniques for measuring grain size and expressing it in terms of some type of grain size of grade scale.
2. Presenting them in graphical or statistical form so they can be easily analyzed.
3. The genetic significance of these data.

Several methods use for the grain size analysis of sedimentary rocks such as settling velocity, microscopic method, sieving method etc. The scope of each of these methods is, however, limited by factors like the degree of consolidation of the sediments, nature and purpose of investigation etc. We use the sieving method to analyze the grain size. It is the common method for laboratory analysis.

The following parameters were calculated in the laboratory-

1. Cumulative curve: Cumulative curve has been drawn on the logarithmic graph paper by plotting the cumulative weight percent retained as ordinate and corresponding grade size as abscissa.
2. Histogram: It is a block diagram which gives the percentage of grains in the grade size present in the sediment. It is constructed by plotting the grade size in the abscissa and the percent weight retained in the ordinate.

Grain size parameter

Different statistical parameters were calculated from cumulative curve, according to Folk and ward methods (1968). The parameters are:

1. Graphic means: An approximation of the arithmetic mean can be arrived by picking selected percentile values from cumulative curve, and averaging these values, by using the following formula:

$$M = \frac{\phi 16 + \phi 50 + \phi 84}{3}$$

Table 2: M Values

Values from	To	Equal
$-\infty$	-1ϕ	gravel
-1	0ϕ	very coarse sand
+0	+1ϕ	coarse sand
+1	+2ϕ	medium sand
+2	+3ϕ	fine sand
+3	+4ϕ	very fine sand
+4	+8ϕ	silt
+8	∞ ϕ	clay

2. Graphic standard deviation (Sorting): Generally sorting means dispersion; character, shape, facies, and size are differentiated from a heterogeneous mixture. The mathematical expression of sorting is the standard deviation. Sorting can be estimated in the field or laboratory by use to hand lenses or

microscope and reference to visual estimation chart that is given is given below:

$$D = \frac{\phi 84 - \phi 16}{4} + \frac{\phi 95 - \phi 5}{6.6}$$

Table 3: D Values

Values from	To	Equal
0.00	0.35ϕ	very well sorted
0.35	0.50ϕ	well sorted
0.50	0.71ϕ	moderately well sorted
0.71	1.00ϕ	moderately sorted
1.00	2.00ϕ	poorly sorted
2.00	4.00ϕ	very poorly sorted
4.00	∞ ϕ	extremely poorly sorted

3. The symmetry of distribution (Skewness): It is determined whether the coaser material exceeds the fine material or fine material exceeds coarser materials. Skewness reflects sorting in the 'Tails' of grain size population, populations with a tail of excess fine particles are said to be positively skewed or fine skewed, it means skewed towards positive values. Populations with a tail of excess coarse particles are negatively skewed or coarse skewed. It means skewed towards negative values. The visual estimation chart of Skewness is given below:

$$S = \frac{\phi 84 + \phi 16 - 2(\phi 50)}{2(\phi 84 - \phi 16)} + \frac{\phi 95 + \phi 5 - 2(\phi 50)}{2(\phi 95 - \phi 5)}$$

Table 4: S Values

Values from	To	Mathematically	Graphically Skewed to the
+1.00	+0.30	Strongly positive skewed	Very fine Skewed
+0.30	+0.10	Positive skewed	Fine Skewed
+0.10	-0.10	Near symmetrical	Near symmetrical
- 0.10	-0.30	Negative skewed	Coarse Skewed
- 0.30	-1.00	Strongly negative skewed	Very coarse Skewed

4. Kurtosis (Peakedness of distribution): Statistically kurtosis measures the ratio between the sorting in the tails (cumulative curve has coarser and finer tails or ends) and the sorting in the central position of the curve. It indicates the behavior of the environment. If the central portion is better sorted than the tails, the frequency curve is called leptokurtic. If the tails are better sorted than the central portion, the curve is said to flat peaked or Platykurtic. As in the case for mean and standard deviation, the grain size units that are used affect Skewness and kurtosis. The visual estimation chart of Kurtosis is given below:

$$K = \frac{\phi 95 - \phi 5}{2.44\,(\phi 75 - \phi 25)}$$

Table 5: K Values

Values from	To	Equal
0.41	0.67	very platykurtic
0.67	0.90	platykurtic
0.90	1.11	mesokurtic
1.11	1.50	leptokurtic

1.50	3.00	very leptokurtic
3.00	∞	extremely leptokurtic

Data table & Ca;culation

Sample no: 01

Location: Ghaghra Rangamati Road Cut Section

Section: L-1

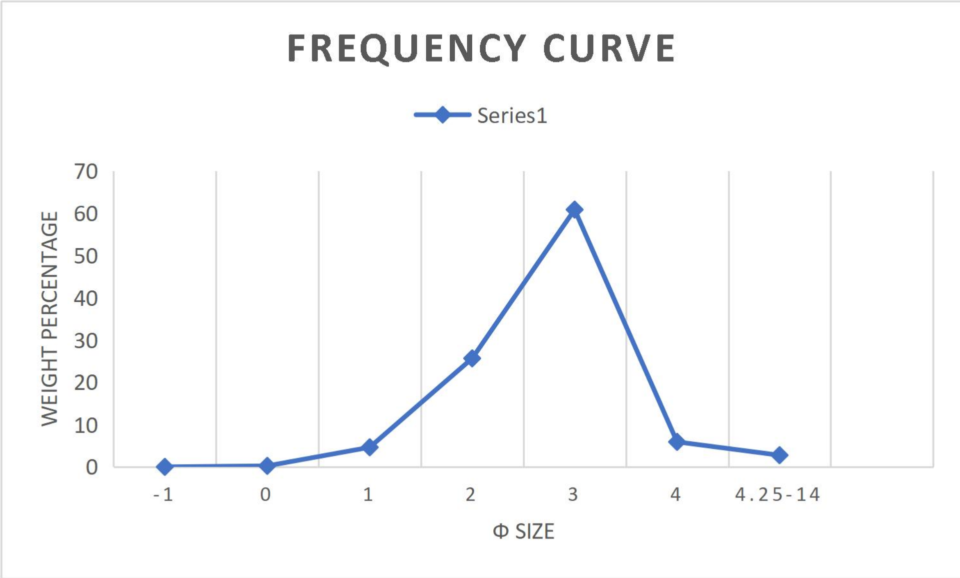
Date: 18-03-22

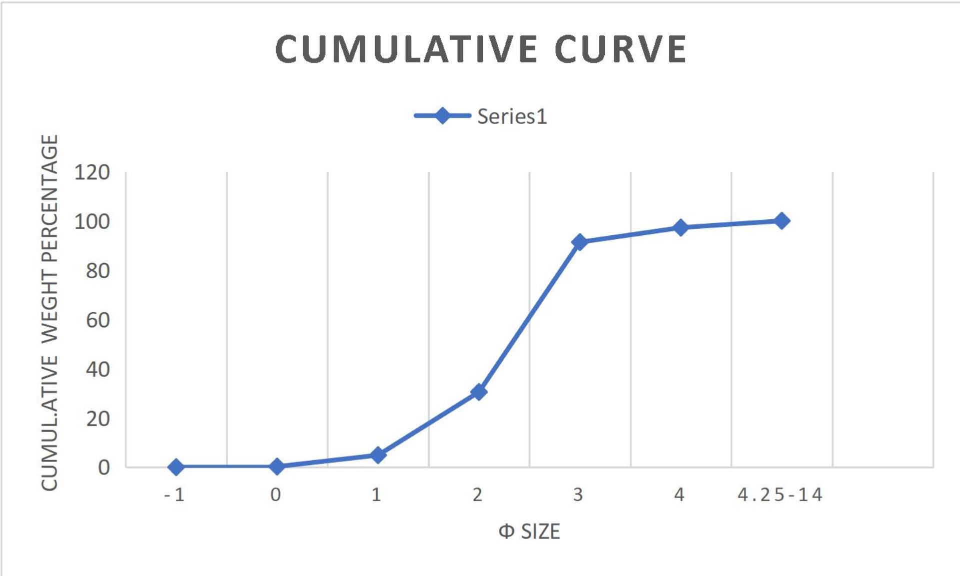
Rock type: Sandstone

Western Flank

Table 06: Different Grain Size Analysis-1

Mash Size (d) (mm)	**ϕ Size (log 2d)**	**Raw Data weight (gm)**	**Weight Percentage**	**Cumulative Weight Percentage**
2	-1	0	0	0
1	0	0.24	0.24	0.24
0.5	1.0	4.61	4.63	4.87
0.25	2.0	25.55	25.65	30.52
0.125	3.0	60.57	60.81	91.33
0.063	4.0	5.89	5.91	97.24
Pan	4.25-14	2.75	2.76	100.00
	Total=	99.6	100	





Input ϕ (Phi) value from the graph paper

Scale	Value	Scale	Value
ϕ05=		ϕ75=	
ϕ16=		ϕ84=	
ϕ25=		ϕ95=	
ϕ50=			

Result:

Type			**Result**	Comments
Graphic Mean				
Graphic Standard Deviation				
Graphic Skewness				
Kurtosis				

<u>Data Table and Calculation</u>

Sample no: 03

Location: Ghaghra Rangamati Road Cut Section

Section: L-29

Date: 20-03-22

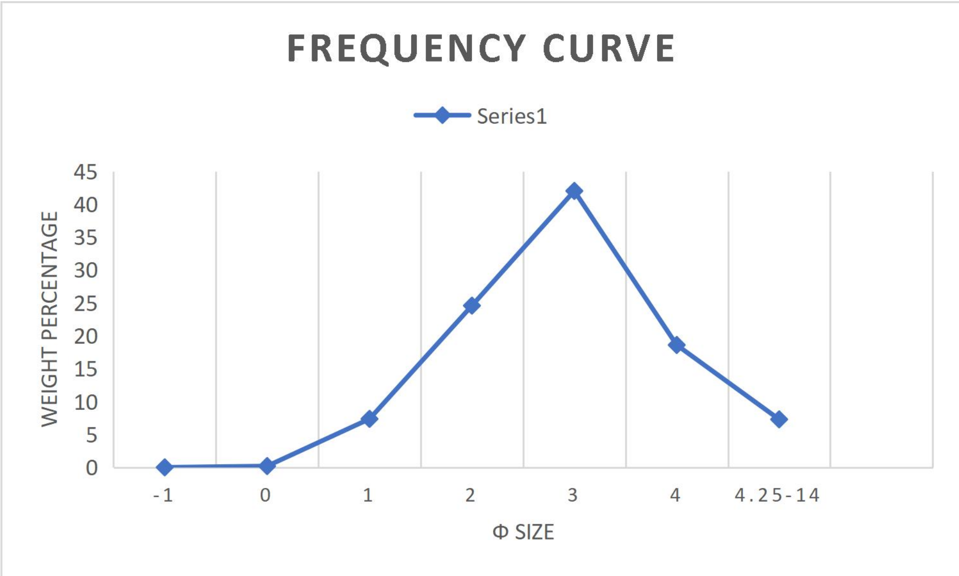
Rock type: Sandstone

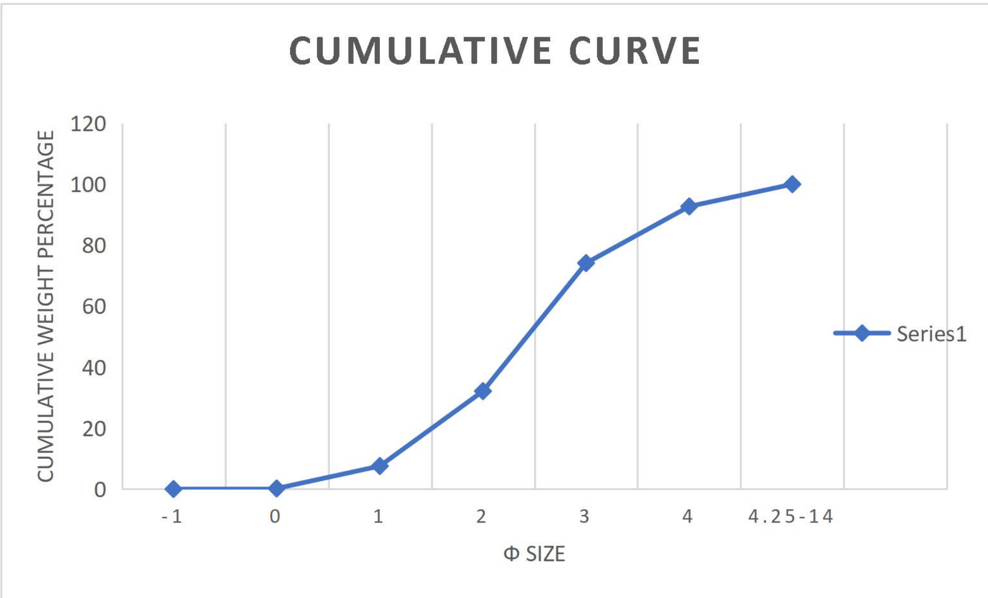
Eastern Flank

<u>Table 07: Different Grain Size Analysis-2</u>

Mash Size (d) (mm)	**ϕ Size (log 2d)**	**Raw Data weight (gm)**	**Weight Percentage**	**Cumulative Weight Percentage**
2	-1	0	0	0
1	0	0.19	0.19	0.19
0.5	1.0	7.36	7.36	7.55
0.25	2.0	24.56	24.57	32.12
0.125	3.0	41.99	42	74.12

0.063	4.0	18.58	18.59	92.71
Pan	4.25-14	7.29	7.29	100.00
	Total=	99.97	100	





Input ᶲ (Phi) value from the graph paper

Scale	Value	Scale	Value

$\phi05=$		$\phi75=$	
$\phi16=$		$\phi84=$	
$\phi25=$		$\phi95=$	
$\phi50=$			

Result:

Type			**Result**	Comments
Graphic Mean				
Graphic Standard Deviation				
Graphic Skewness				
Kurtosis				

Special features

Primary Sedimentary structure

Sedimentary Structures are large scale features produced within a depositional environment during or no longer after deposition. Sedimentary structures include all kinds of features formed at the time of deposition. Sediments and sedimentary rocks are characterized by bedding, which occurs when layers of sediment, with different particle sizes are deposited on top of each other. These beds range from millimeters to centimeters thick and can even go to meters or multiple meters thick. Structures that are produced at the same time as the sedimentary rock in which they occur are called primary sedimentary structures. Examples include bedding or stratification, graded bedding, and cross-bedding. Whereas other sedimentary structures like concretions form well after deposition and penecontemporaneous modification are known as secondary structures. Finally, there is another type of structure, called organic sedimentary structures which includes structures like organic burrows and tracks. Based on our field observation we found primary sedimentary structures such as Lenticular Bedding, Nodular Structure, Cross Bedding, Wavy Bedding, Trough Cross Bedding etc. We also observed secondary structures like iron concretions. Finally, we found some organic sedimentary structures such as burrows and plant impressions.

1. Nodular Structure: Nodular is used to describe sediment or sedimentary rock composed of scattered to loosely packed nodules in matrix of like or unlike character. It is also used to describe mineral aggregates that occur in the form of nodules. We found this structure only in Bluish gray shale and it was the fundamental structure of that rock type.
2. Wavy Bedding: Wavy bedding is a form of heterolithic sediment characterized by interbedded rippled sands and mud layers. Based on our observation, wavy bedding was found in both bluish gray shale and sandy shale.
3. Lenticular Bedding: Lenticular Bedding is a structure formed by interbedded mud and ripple cross laminated sand in which the ripples or sand lenses are discontinuous and isolated in both a vertical and a horizontal direction. We also observed this structure in Sandy Shale and Bluish Gray Shale.
4. Flaser Bedding: Flaser beds are a sedimentary, bi-directional, bedding pattern created when a sediment is exposed to intermittent flows, leading to alternating sand and mud layers. While flaser beds typically form in tidal environments, they can (rarely) form in fluvial conditions - on point bars or in ephemeral streams. We observed this structure in Sandy Shale.

5. Trough Cross Bedding: Trough cross bedding consists of cross bedded units in which one or both bounding surfaces are curved. The units are trough shaped sets consisting of an elongate scour filled with curved fore set laminae that commonly have a tangential relationship to the base of the set. This structure was observed in Yellowish Brown Sandstone.
6. Tabular Cross Bedding: Tabular (planar) cross-beds consist of cross-bedded units that are large in horizontal extent relative to set thickness and that have essentially planar bounding surfaces. Tabular crossbedding is formed mainly by migration of large-scale, straight-crested ripples and dunes. It forms during lower-flow regimes.

Secondary Sedimentary Structures

1. Iron Incrustation: A crust or hard coating of anything upon or within a body, as a deposit of lime, sediment, etc., from water on the inner surface of a steam boiler. We observed this structure in almost every section.
2. Clay Gall: When a patch of clay or mud dries out, the upper surface cracks and peels away from the upper layers. These thin leaves of clay may occasionally be transported a short distance and deposited in sand or in some kind of sediment in the form of flat or lensed shape clay galls, generally oriented parallel to the bedding. We observed this structure in Yellowish Brown Sandstone and others.

   Organic Sedimentary Structures

   1. Grooves and Burrows: A burrow is a hole or tunnel excavated into the ground by an animal to create a space suitable for habitation, temporary refuge, or as a byproduct of locomotion.

CHAPTER THREE: STRUCTURE

Major Structure

Fold

Folds are the waves of undulation found in the rock unit of the earth surface that forms in response to directional forces (Billings M.P., 1986). Force may be horizontal or tangential towards a common point or plain from opposite direction.

Based on our observation the first and foremost major structure that we observed and analyzed is an anticline, known as the "Sitapahar Anticline". Our observation suggests that, Sitapahar anticline is an asymmetric anticline. The western limb of the anticline being steeper than the eastern limb indicates its asymmetric nature. The western limb of the anticline is interrupted by a major fault which strikes almost parallel to the axis of the anticline. The axis of the fold is running in NNW-SSE direction parallel to the general trend of the regional strike.

It lies in the east of the Patiya and the west of the Gilasari and the Belasari structures. On the north of the Sitapahar anticline, Changotaung anticline is situated while bandarban anticline is located on the south. The Sitapahar anticline is a N20°W-S20°E trending structure plunging 6° in S18°E. The structure is about 40 km in length. Its steeper western flank is overturned in some places (Geological Structure, 2015).

The fold is evidenced by:

1. The measured attitude of the rock strata suggests that the beds are dipping in opposite direction from a place that represents an imaginary line.
2. The observed Nodular Bluish Gray Shale (Unit-D) was found in the axial region and it is oldest rock unit of the analyzed phenomena. This observation corroborates our claim that, the phenomena is an anticline.
3. The length of the eastern flank being less than the length of the western flank suggests that the anticline is asymmetric.

Fold Symmetry

Folds can be termed as symmetrical and asymmetrical based on the length of both limbs of the fold. If a fold has limbs of relative equal length, it can be termed as symmetrical. Otherwise, in case of distinct limb lengths, it is called asymmetrical. Asymmetrical folds generally have an axis at an angle to the original unfolded surface they formed on. Thus, from the above observation, it can be said that the fold is an Asymmetrical Anticlinal fold.

Fault

Faults are planar fracture or discontinuity in a volume of rock across which there has been significant displacement as a result of rock-mass movements. In this fieldwork two major faults are observed:

i. Longitudinal fault (thrust and/or reverse fault on the both flank) and
ii. Back thrust fault (eastern flank)

In the investigated area on the eastern flank of the anticline these faults are roughly N-S trending. This is more or less parallel to the axis of the structure.

The fault is evidenced by:

1. Abrupt change in dip amount.
2. Presence of opposite dip direction within short distances.
3. Visible displacement of layers.
4. Abruptly change in topography.

Minor Structure

Minor Folding

In this fieldwork some minor folds are found. They are mainly parasitic fold drag fold and kink band fold.

1. Parasitic Fold: Fold of small wavelength and amplitude which usually occurs in a systematic form superimposed on folds of larger wavelength. Parasitic folds usually show typical S and Z asymmetric profiles on their limbs and M profiles in the hinge regions. In this observed area Z-fold has been found, which is long- short-long in shape. Generally, is type of parasitic folds are found in clockwise respect to long limb, mostly on left flank. But in this area, these folds are found in right flank which indicate there’s a small scale fault.
2. Drag Fold: A minor fold, usually one of a series, formed in an incompetent bed lying between more competent beds, produced by movement of the competent beds in opposite directions relative to one another. Drag folds may also develop beneath a thrust sheet.

Joint

Joint is a fracture along which no appreciable movement has been occurred. Although they can occur singly, they most frequently occur as joint sets and systems. A joint set is a family of parallel, evenly spaced joints and joint system consists of two or more intersecting joint sets. In this study following types of joint sets are observed mainly:

1. Parallel Joint: Joints that are parallel to the bedding planes in a sedimentary rock are called Parallel joint.

2. Oblique Joint: Joints which run in a direction that lies between the strikes and dip direction of the rock beds, are called Oblique Joints.

Fracture

In this fieldwork some minor faults or fractures are observed. Fracture is any separation in a geological formation, such as a joint or a fault that divides the rock into two or more pieces. Fractures has no orientation like joint.

Unconformity

Unconformity is a buried erosional or non-depositional surface separating two rock masses or strata of different ages, indicating that sediment deposition was not continuous. In general, the older layer was exposed to erosion for an interval of time before deposition of the younger layer, but the term is used to describe any break in the Sedimentary geologic record.

Marker bed

A "marker bed" is an important concept in geology. It is a bed of rock strata that are easily distinguished and are traceable over a long horizontal distance. A marker bed is very useful in determining the chronological order of geological events and correlating them from one location to another. In the studied area we found some marker beds indicating structural deformation and faulting.

CHAPTER FOUR: LITHOSTRATIGRAPY

Stratigraphy of the section

Stratigraphy is the study of stratified rocks which deals with original succession and age relation of rock state, distribution, and lithologic correspondence, fossil content and geochemical properties of strata. The main principle of stratigraphy is based upon sedimentary petrology and the basic principle of stratigraphy (Dunber and Rodgers, 1957). The Ghagra-Rangamati Road Cut section is characterized by several types of rock that are exposed along both sides of the road. By observing the rock types of the investigated area thoroughly, four rock units were found. They are as follows:

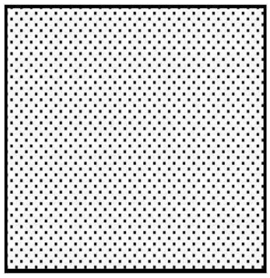
Unit A- yellowish brown loosely compacted sandstone youngest

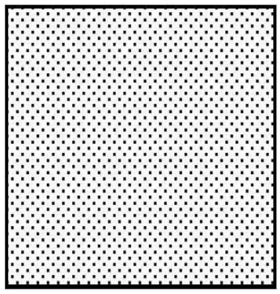
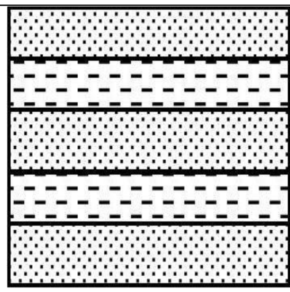
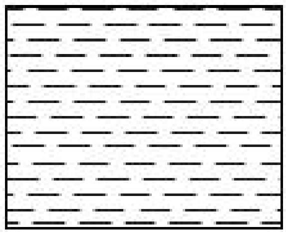
Unit B- moderately compated yellowish brown sandstone

Unit C- sandyshale and

Unit D- nodular bluish gray shale oldest

Table 8: Stratigraphy of Sitapahar Anticline Structure

Possible age	Stratigraphic Unit	Major Rock Types	Description	Symbol
Youngest	Unit-A	Loose Yellowish Brown Sandstone	Exhibiting yellowish brown color, medium to coarse grained sand sized particles, massive structured, highly permeable and friable, ferruginous cementing materials.	

	Unit-B	Moderately Compacted Yellowish Brown Sandstone	Brownish colored, composed of medium to coarse grained sand sized particles, ferruginous cementing material. Thin layer of clay and clay galls are also present.	
	Unit-C	Sandy shale	Sandstone is yellowish brown to brownish in color, medium to fine grained, ferruginous cementing material. Shale is grayish colored, fissile nature, argillaceous cementing material.	
Oldest	Unit-D	Nodular Bluish Gray Shale	Bluish gray colored, composed of fine grained clay sized particles, shows nodular structure.	

Correlation with Regional Stratigraphy

Correlation of the rock formation of different regions to the regional strata is an important part of Stratigraphy. Correlation means the process by which stratigraphy specialists' attempts to determine the mutual time relations of a local section (Dunber and Rodgers, 1957). Lithology and Stratigraphy are the possible means to the correlation of the studied area comparing the rock types of the surveyed area with that of Assam by vertical and horizontal cross section. Our investigated area, which lies on the eastern folded belt of Bengal Basin, was developed as the South extension of Assam Himalaya in the Mio-Pliocene age. The stratigraphy of Assam has been well established.

Table 9: Correlation between rock units of Ghagra- Rangamati road cut section and Assam, India.

Ghagra- Rangamati Road Cut Section			**Stratigraphy of Assam**			**Probable age according to (Reimann, 1993)**
Formation name	Rock Unit	Lithology	Group	Formation	Lithology	
Loose Yellowish Brown Sandstone	A	Exhibiting yellowish brown color, medium to coarse grained sand sized particles, massive structured, highly permeable and friable, ferruginous cementing materials.		Dupi Tila	Gray to Yellowish claystone, sandstone, siltstone etc.	Pleistocene
Moderately Compacted Yellowish Brown Sandstone	B	Brownish colored, composed of medium to coarse grained sand sized particles, ferruginous cementing material. Thin layer		Tipam Sandstone	Yellowish to Brown sandstone and very subordinate shale.	Pliocene

		of clay and clay galls are also present.				
Sandy Shale	C	Sandstone is yellowish brown to brownish in color, medium to fine grained, ferruginous cementing material. Shale is grayish colored, fissile nature, argillaceous cementing material.		Bokabil	Alternation of siltstone and shale with calcareous band.	Upper Miocene
Nodular Bluish Gray Shale	D	Bluish gray colored, composed of fine grained clay sized particles, shows nodular structure.		Bhuban	Siltstone, silty shale, sandy shale and sand stone.	Lower Miocene

CHAPTER FIVE: ECONOMIC GEOLOGY

The abundance of materials that are of immense economic significance, is simply inevitable. During the extensive fieldwork in the area, we found the abundant existence of sandstone, silt, shale, and mudstone etc., each of which is equally important both economically and geologically. The most economically important materials and their significances are described below:

Constructional Purpose

Among the observed rock types, sandstone, shale and silt are used especially as constructional material in building, industry or any type of constructional site. Calcareous sandstone band is used as stone chip in construction.

Glass Industries

The area has colossal amount of highgrade sandstone which is of vital importance for glass industries and manufacturers.

Source of Hydro-carbon

The investigated area (Sitapahar Anticline) is considered as highly prospective for hydrocarbon exploration. The prospect of hydrocarbon occurrences of the area requires some points such as source rock, reservoir rock, trap and timely migration and thermal maturity. The silty shale of the oldest unit shows some organic content that may be considered as the source of hydrocarbon generation.

Use of pebble, cobble and gravels

These coarser grained sedimentary rocks are used in railway, highway, and bridge construction. In addition, these are used as grinding or frictional element in many industries.

Water resource & Hydroelectric power generation

Kaptai Lake is one of the biggest lakes of Bangladesh. It is a good source of fresh water. This lake plays a very important role in the economy of this area. Due to excessive velocity and amount of water, this lake could be used as hydroelectric power generation source.

Tourism

Rangamati hill tract area is significant as a tourist interest spot of Bangladesh.

CHAPTER SIX: CONCLUSION

The investigated area is a hilly region with the presence of irregular topographical features and high-altitude hillocks. It is an asymmetric anticline, associated with its gently dipping eastern flank and steeper western flank. The purpose of this field trip was to investigate the sedimentology, structures, tectonic setting, and depositional environment of the area and to construct a general stratigraphy of the investigated area which was later correlated with the well-established regional structure. This field report also gives an overview on the economically significant zones, structures and rock types. The observed Sitapahar anticline, locating between Changotaung anticline on the north and Bandarban anticline on the south, is a region of irregular topography with the general NNW-SSE trend. From geological point of view, it is a tectonically disturbed zone, giving rise to major faults in the associated areas. We observed, three prominent thrust faults in the surveyed area.

The outcrops are generally poorly developed or already eroded out due to natural processes and anthropogenic activities. Yet, we managed to investigate enough exposures and acquire adequate information to analyze and interpret the rock formations of the area and to construct a stratigraphic sequence consisting of four distinct stratigraphic units based on the interpreted data. The four major stratigraphic units are, from youngest to oidest, Unit-A, Unit-B, Unit-C, and Unit-D. The major rock types observed in these formations are Yellowish Brown Sandstone, Bluish Gray Shale, Sandy Shale, and Silty Shale while some of the major structures Cross Lamination, Nodular Structure, Flaser Bedding, Lenticular Bedding, Wavy Bedding, Clay Gall etc. These major stratigraphic units were later correlated with the stratigraphy of Assam, on the basis of lithology, sedimentary sequences. Based on this observation, it can be concluded that, the investigated area consists of four major stratigraphic formations. These are, from oldest to youngest, Bhuban, Boka Bil, Tipam, and Dupi Tila, aged between Miocene to Plio-Pleistocene.

By observing the color, texture, grain compaction, and structure of these rock units, it is assumed that, the depositional environment of Unit-A and Unit-B is fluvial, Unit-C and Unit-D is tidal.

Furthermore, based on our observation, the investigated area is economically significant for the dependence of construction industries on the rocks found in this area, and for the possibility of the presence of hydro carbons. Thus, it can be said that, proper investigation in mandatory for the detection of oil and gas in this area.

Finally, it can also be added that, Sitapahar anticline is an excellent place for a Sedimentologist and for a Structural Geologist, to further investigate the area extensively.

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