ABSTRACT

This field report is made based on the geological investigation at the Sitakund Hill Range and its adjacent area which represents an asymmetrical anticlinal overturned fold of about 64 km long and 8 km wide and lies in the eastern-west part of Bangladesh. It is doubly plunging fold having its axis running NNW-SSE direction (Latif & Hossain). Its western flank is much steeper whereas the eastern flank is gentle and long.

This report prepared in the view of physiography, petrography, stratigraphy, structural analysis, sedimentology, depositional environment and economic consideration. Traverse method was used throughout the field work for measuring the distance from station to station and also for determining the spot location in the supplied map of Sitakund Area.

Five stratigraphic units have been identified throughout our investigated areas, among which the relative age of these units was measured. They are described briefly below including the major rock type of these units (From Oldest to Youngest):

These are Unit-A; Mudstone, Unit-B; Shale, Unit-C; Alternation of Sandstone and Shale; Unit-D; Yellowish Brown Sandstone and Unit-E; Variegated Sandstone. The absolute age of these units were not measured.

The common sedimentary structures are lenticular and wavy bedding, nodular structure, flaser structure, ripple cross lamination and trough cross lamination, mud cracks, Iron concretions and clay gall, burrows etc. The depositional environment of these units was determined based on the sedimentary structure as well as lithology. The depositional environment of Unit-A is Shallow Marine, depositional environment of unit-B is Deltaic to Shallow Marine, depositional environment of Unit-C is Shallow Marine and depositional environment of Unit-D and E is Fluvial. Throughout this field work many major structures like fault and fold was observed. Based on our investigation it is estimated that Sitakund Area is an Asymmetrical Anticlinal Overturned Fold.

Our studied area was not so rich in economic deposits, except a vast use of Sandstone and gas seepages in this area proves the presence of gas, but the economic value of this gas is poor.

This report deals with the physiography, topography, stratigraphy, petrography of the studied area.

Chapter one: Introduction

Geology is the subject of natural science, so for me as a student of Geology, the whole world is my laboratory. Geological field work is one of the most important and mandatory course for a geology student. It is also necessary to provide newer information for geo-scientists.

Field geology may be defined as the study of rocks and rock materials, investigated in their natural environment and in their natural relations to one another.

The investigated areas of Sitakund hill range of Chittagong district which is an asymmetrical overturned anticline. As 'Geology' is the subject of natural science, so it is important to obtain the fundamental knowledge based on practically observable studies. Theoretical knowledge and laboratory analysis are not sufficient to understand the perfect knowledge of geology. So, Sitakund anticline at Chittagong, Bangladesh is one of the prominent practically observable areas of the country for doing such practically observable studies or Field Work.

Sitakund hill range is formed by many minor and major structures. Many fold and joint are present within the formation or bedding. Fault escarpment present in the hill range which is a major structure. All of the structure observed in folded hill range. The overall hill range of Sitakund is an anticline which is a folded structure. It clarifies the concept of structural mechanism and environmental condition which has great effect on structural mechanism.

This report deals with the result of field data and collected sample from different section of Sitakund Hill Range to describe lithology, structure and economic important. In one word this report is designed to show the geology of Sitakund Hill Range area.

1.1: Aim and Objectives

Geology is an Earth science, which provides valuable information about the history of the Earth and required for industrial and urban planning of the region as well as for the exploration of oil, gas and minerals. Field study helps to clarify the principle of the geology that state as "The present is the key to the past" introduced by James Hutton (1726-1797). However, the purpose of the field study may be described as bellow:

a. To require practical knowledge of the geology of the area.
b. To investigate the nature and types of the exposed sedimentary rocks of the studied area.
c. To know the depositional environments of these rock.
d. To know the topographic patterns of the studied area.
e. The established of individual lithostratigraphic units as a basis of correlation.
f. To study different sedimentary, stratigraphy and structural features of studied area.
g. Petrographic study of the sample.
h. Physiography, vegetation and calculation and population of the investigated area.

i. To correlate the observing section with standard geologic column to establish stratigraphic sequence of rock units and standard formation of the sedimentary rocks in the region.
j. To measure the attitude of beds.
k. Finally to make a compressive geological field repot and convert a base map into -

GEOLOGIC MAP CAN BE MADE BY COLLECTING DATA AND OTHER INFORMATION.

1.2: Methods of Investigation

The areas that were being investigated was taken along the road-cut section and stream cut section, where the rocks are being well exposed. For surveying in the field, traversing method was used. By this method distance were measured by a process which known as steeping/pacing. Then step/pace count was converted into feet. One member of each team counted him/her steps. We had G.P.S (Global positional system) from which we measured longitude, latitude. Clinometers were also used for measuring the attitude of beds. The information was plotted on the map to get a clear view of Sitakund area hence to convert the base map into a geological map.

Rock samples have been studied visually and observations have been written in field notebook. Then plotted on the map according to their geographic locations, One of the key observations include identification of the sedimentary structures(if any) and understand the significance of that structure in the context of depositional setting.

Mapable 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.

1.3: Location and Extent

The Sitakund Anticline is situated in the Eastern-West part of Bangladesh and a part of Chittagong Division and Chittagong hill tracts and lies in the western part of the Chittagong Tripura Fold Belt.

Table-1: Location and extent of the study area

Name of the section	Geographic Position	Distance from the Base camp (from map) (km)	Length of the Section (km)
Labanakhya Charra Section	Latitude: 22˚39'48″ N to 22˚40'30″N Longitude: 91˚39'35″ E to 91˚40'15″E	7.467	1.40
Zeorzory Charra Section	Latitude: 22˚38'30″N to 22˚38'50″N Longitude: 91˚39'30″E to 91˚40'15″E	5.180	4.74
Barabkund Section			1.50
Bariadhala Section	Latitude: 22˚40′35″ N to 22˚42'1″5″N Longitude: 91˚39'E to 91˚42'15E	8.380	11.25

1.4: Accessibility

Sitakund thana is 32 km far from Chittagong city and 209 km far from Dhaka (ref - Bangladesh Map). Sitakund is well connected with both Dhaka and Chittagong by metal highway and railway line. The metal highway and railway line runs parallel to the western side of the Sitakund Hill range. The sections that we investigated in the Sitakund Area are accessible by two ways-

First one is by bus or tempos to reach to these sections, Secondly, by foot to reach the areas which is unreachable by tempos or busses. All of the sections that we investigated in Sitakund were easily accessible by these transports.

 Zeorzory Charra section is connected by Dhaka-Chittagong railway line and then foot path.

 Labanakhya Charra section is a stream cut section and is connected by metal road in which tempos and mini busses are mostly used for transportation.

 Barabkund Section is connected by metal roads and then foot path is used.

 Lastly Bariyadhala section is also connected with metal roads in which tempos were used to travel the distance covered by metal roads and then foot path is used.

1.5: Field Equipment

1. Base Map: To locate the observed information (Attitude, lithology) in the base map.

2. Clinometer: It is used for structural measurement (Strike, Dip and Dip Amount).

3. Hammer: It is used to find out proper beds or unweathered bedding planes by removing the weathering beds and is used for sampling.

4. Scraper: To expose the bed and collect sample.

5. Pocket Lens: To identify grain size and shape.

6. Hydrochloric Acid (HCl): To identify the cementing materials of the rock.

7. Sample Bag: To collect the samples.

8. Field Notebook: To note all the field information.

9. Camera: To take the photographs.

Chapter Two: Physiography

2.1: Physiography

The physiography of the Sitakund area can be divided into three subdivisions. These are the western, middle and eastern zones. The general trends of these zones are ~NNW-SSE.

The western zone is characterized by alluvium and coastal plains. The average elevation of this zone is 4-5m above mean sea level (MSL). The middle zone is marked by smaller foot hills with lower elevation (<80m above MSL). A sharp change in elevation separates the eastern zone from the middle zone. The average elevations of these hills are 250m while the highest peak is the Chandranath Temple (352m above MSL). These relatively high elevation hills of the eastern zone gradually decrease its elevation to the further east and become plain land near Halda Valley.

2.2: Drainage

Numerous streams and streamlets are present in the Sitakund Hill Range. Locally, these streams are called chara. Lengths 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 the Sitakund Hill Range is dendritic pattern.

Several V-shaped valleys and water falls are present in this area. Presence of such features indicates that the area is possibly tectonically active and subsequently uplifted and being subjected to high erosion.

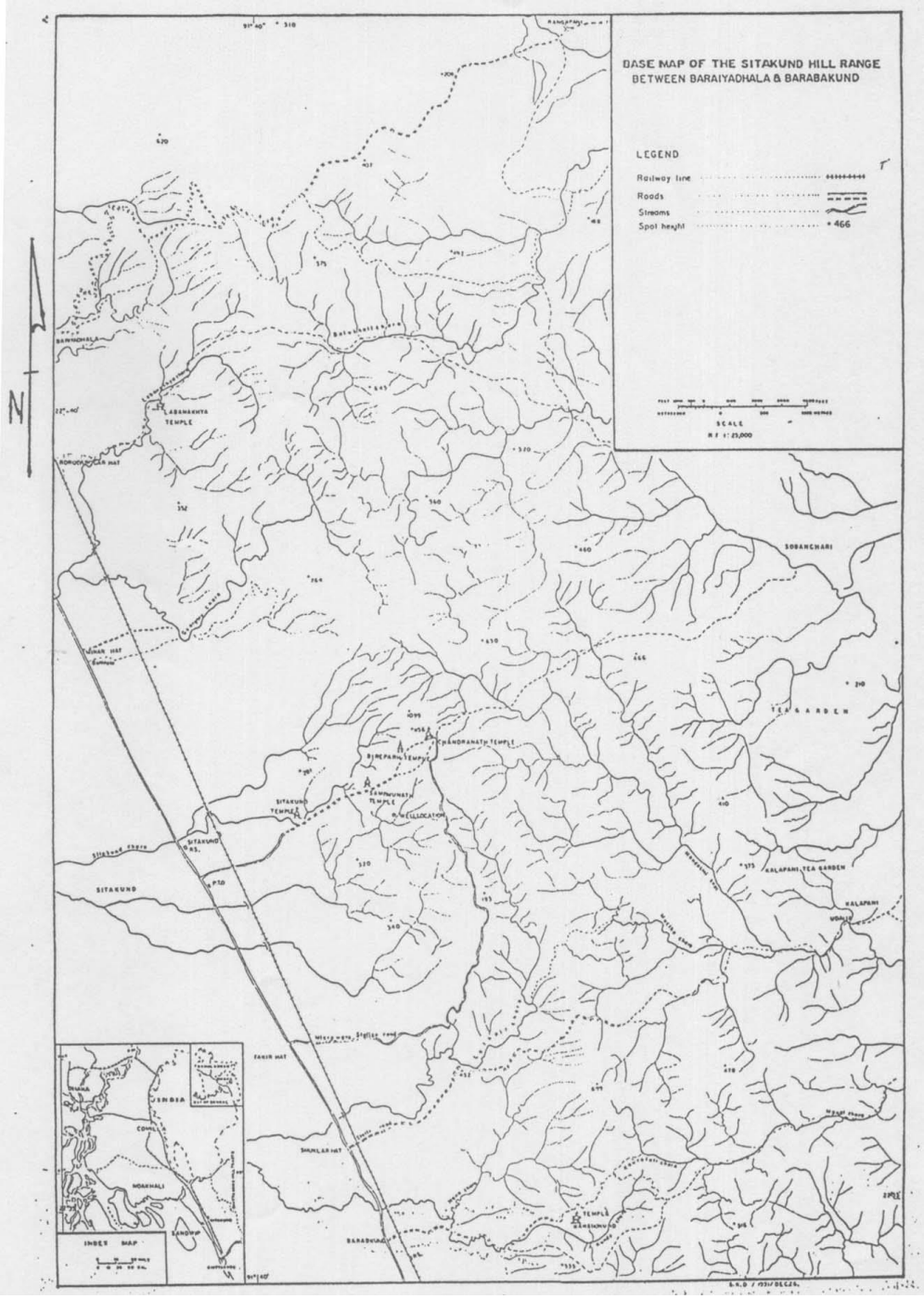

Fig (2): Photograph showing the drainage of Sitakund Hill Range.

2.3: Vegetation

Chittagong Hill Tracts contains ten percent of land surface of the country, of which 25 percent is covered by dense forest. Most of which is deciduous forest and little part is covered with coniferous forest. The study area (i.e. Sitakund) is also covered with dense forest. However, population growth and climate change have direct impacts on the local vegetation.

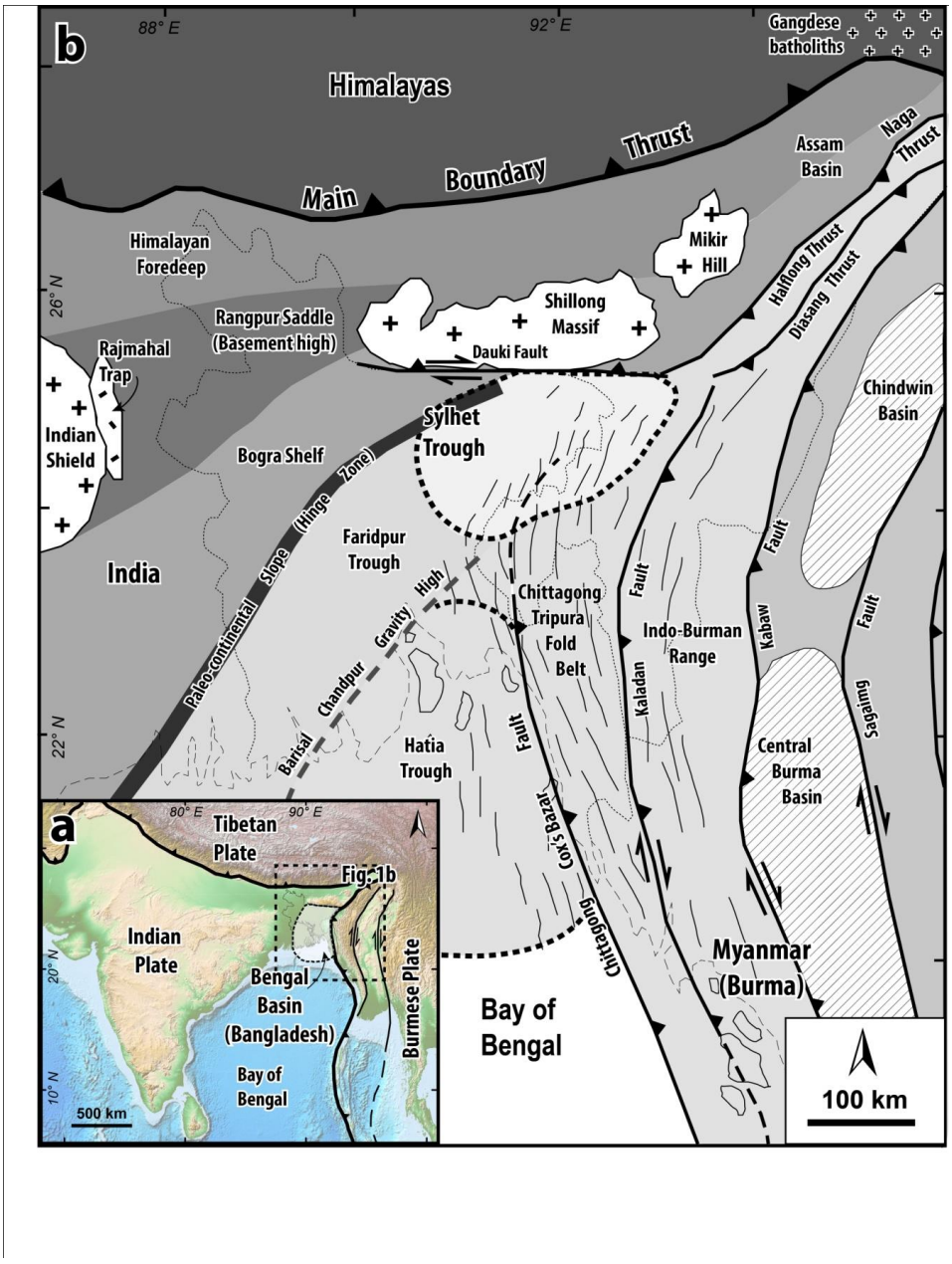

Fig (3): a. Location of the Bengal Basin in the context of the Indian, Tibetan and Burmese plates.

b. Map shows the tectonic elements of the Bengal Basin and location of the study area (modified after Alam et al., 2003)

Chapter Three: Geological Setting, stratigraphy and tectonic evolution of the Bengal Basin

Bangladesh occupies much of the Bengal Basin which is located at the northeastern corner of the Indian plate (Fig 3a). Development of the Bengal Basin has been controlled by the collision of the Indian plate with the Burmese and Tibetan plates. Major subdivision of the Bengal Basin includes:

(a) The stable shelf in the northwest,

(b) The deeper foredeep basin in the central part,

(c) The fold belt to the east (i.e., the chittagoing Tripura Fold Belt or (CTFB) (Fig 3b). Sitakund is located in the western part of the Chittagong Tripura Fold Belt (Fig 3b).

Sedimentation and tectonic evolution of the Bengal Basin (including the Sitakund Area) inaugurated with the Jurassic to early Cretaceous Gondowana break-up (Shamsuddin and Abdullah 1997; Alam et al., 2003; Najman et al., 2008). Bengal Basin was evolved from a pre-Oligocene to Miocene (Johnson and Alam, 1991). Later (possibly during the Pliocene to Holocene), this foreland basin is more linked to the south directed over-thrust of the Shillong Massif (Johnson and Alam, 1991). Alternatively, Rahman and Faulp (2003a) suggested that the basin was formed as a portion of the foreland basin of the Himalayan Orogen and the Indo-Burman Range.

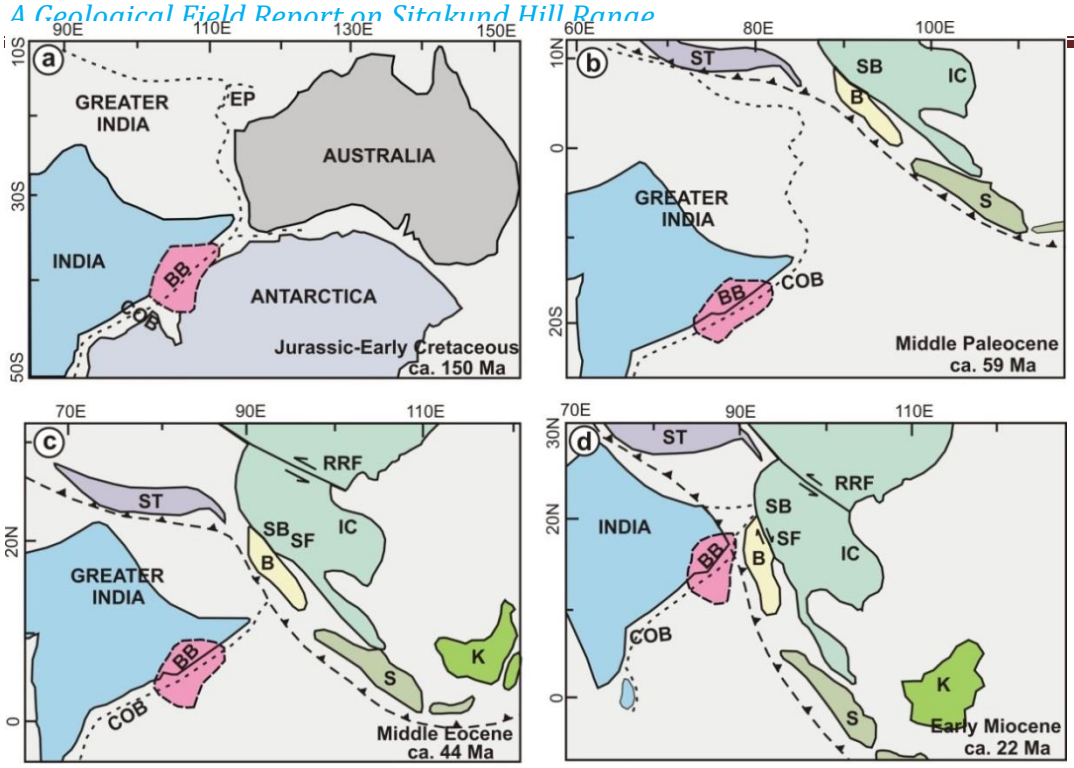

Fig (4): Tectonic evolution of the Bengal Basin: (a) Jurassic to Early Cretaceous rifting, (b) Middle Paleocene soft collision, (c) Middle Eocene hard collision, (d) Early Miocene remnant ocean basin development (after Alam et al., 2003).

Stratigraphy of the Bengal Basin shows Cenozoic clastic sediments with a limestone layer in lower part (Fig.5). The sediments within the basin demonstrate an evolution from shallow marine through tidal to a fluvial depositional setting (Alam et al,. 2003, Johnson and Alam, 1997, Khanam et al., 2017).

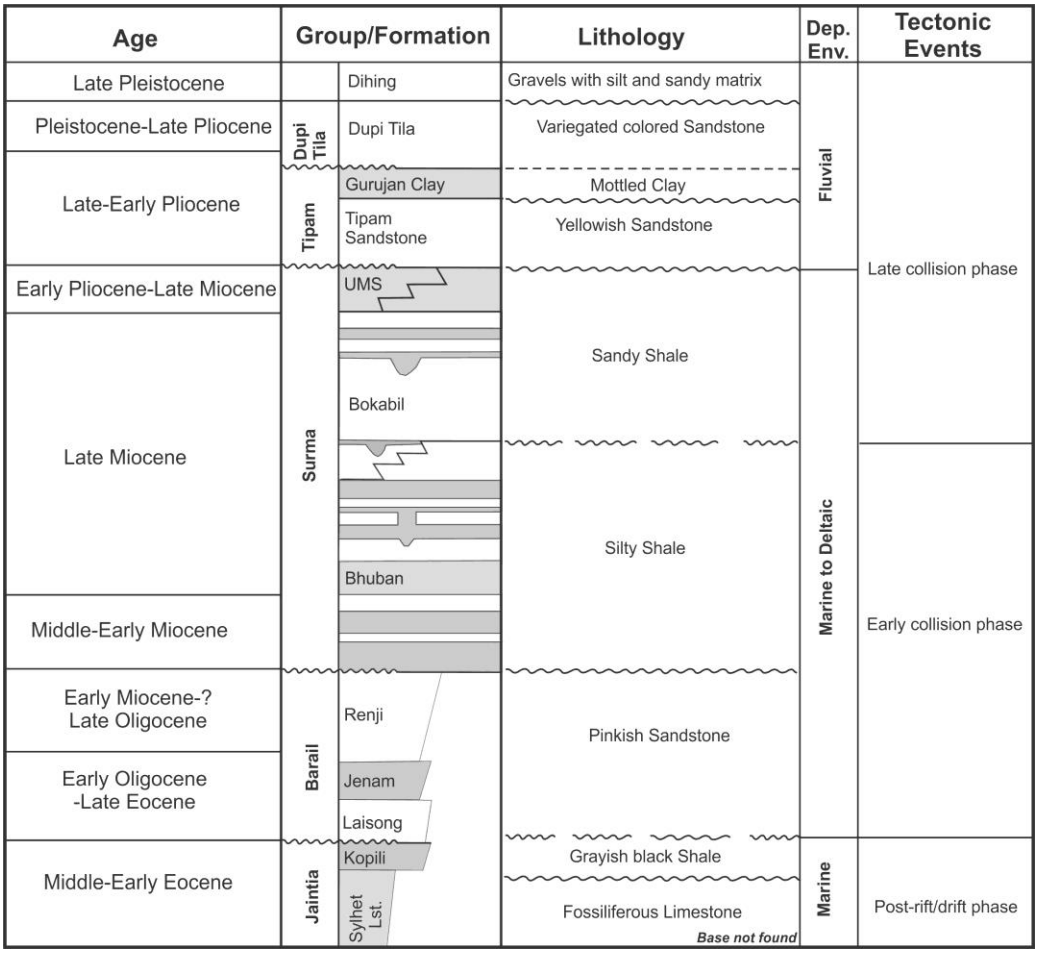

Fig (5): Summary of stratigraphy of the Bengal Basin (after Alam et al., 2003, Johnson and Alam 1997, Najman et al., 2008, Reimann 1993, Shamsuddin and Abdullah 1997).

The oldest exposed stratigraphic unit of the Bengal basin (only exposed in the Sylhet area, NE Bangladesh) is the Jaintia Group that includes the Sylhet Limestone and Kopili Shale formations of Eocene age (Reimann, 1993;Alam et al.,2003). Overlying the Jaintia Group is the Barail Group which composed of massive medium –grained sandstone interbedded with siltstone. The Miocene Surma Group includes the Bhuban (Lower) and Boka Bil (Upper) Formation. Both the formations are consisting of dark gray shale, siltstone, fine to coarse-grained sandstone, and occasional intraformational conglomerate. Overlying the Surma Group, the Tipam Group includes the Tipam sandstone and the Girujan clay formations. The youngest unit is the Dupi Tila Formation comprises of mostly sandstone, overlies the Girujan clay Formation.

In the Chittagong Tripura Fold Belt, not all the above-mentioned stratigraphic units are exposed. More specifically, the Jainta (Sylhet Limestone and Kopili Shale) and Barail groups are completely absent on surface.

Chapter Four: Petrology

Petrology is the study of rocks, their occurrences, composition, origin and evolution. Petrology focuses primarily on the rock formation, or petrogenesis. A petrological description includes definition of the unit in which the rock occurs, its attitude and structure, its mineralogy and chemical composition, and conclusions regarding its origin.

Based on our field observation, our main focus of studying the rocks was held on four different sections. These are:

A. Labanakhya Charra Section
B. Zeorgory Charra Section
C. Barabkund Section
D. Bariyadhala Section

Short descriptions of these sections are given below:

A. **Labanakhya Charra Section:** This section is about 7.725 km NNE from Sitakund Railway Station. The area that we investigated in this section is approximately 1.4 km. This section is a hilly region including many hills, hillocks, streams. At the end of our investigated area we found a waterfall named "Sahasradhara".
   Gas Seepage was one of the interesting features of this area, which may be an evidence of zone of weakness (possibly fault).
   We investigated several types of rock types including Sandy Shale, Thin Bedded Sandstone, Mudstone, Silty Shale and Calcareous Sandstone.
   We also inquired about many sedimentary structures including Flaser and Lenticular Structure, Lamination, Nodular Structure.

B. **Zeorgory Charra Section:** The area we investigated in this section is approximately 4.74 km. This area is densely vegetated. Many hills, hillocks, streams were seen. There were also many cultivated land in the area that we investigated.
   Several types of rock types were seen in this section including Sandstone, Mudstone, Silty Shale, Calcareous Sandstone and also some Sandy Shale which were actually minor. The major sedimentary structures seen in this section comprising Massive Structure, Nodular Structure, Lenticular and Wavy Bedding, Ripple Lamination, Trough Cross Lamination and Micro Cross Lamination.

C. **Barabkund Section:** The investigated area in this section is approximately 1.50 km. This area is densely vegetated as the previous sections covering many hills, streams and streamlets.
   Gas Seepage was also seen in this section. Fault Escarpment was also one of the interesting features of this area.

Rock types seen in these areas are Silty Shale, Mudstone, Calcareous Sandstone, and Sandy Shale.
Major Sedimentary Structures are Nodular Structure, Bedding Internal Lamination and also some minor Thick Bedding.
Fragments of coal were also found in this section.

D. **Bariyadhala Section:** This area is situated within the latitude 22°41´25´´and longitude 91°39´55´´. The investigated area in this section is approximately 11.25 km.
This section is highly elevated and characterized with hills, hillocks and valley. The vegetation is also very dense.
The major rock types of this section are Sandy Shale, Mudstone, Silty shale, Calcareous Sandstone, Medium Grained Sandstone, Variegated Sandstone and Clay Gall.
Sedimentary Structures found in this section including Parallel Lamination, Lenticular and Wavy Bedding, Thin Bedding, Micro Cross Lamination, Nodular Structure, Trough Cross Lamination, Flaser Structure and Cross Bedding.

Our main focus of studying the rocks was divided into two major parts:

4.1: Major Rock Types.

4.2: Sedimentary Structures.

Description of rock types and sedimentary structures are as follows.

4.1: Major Rock Types

4.1.1: Mudstone

Mudstone is gray colored. It is dominantly composed of clay and silt size particles. It mainly shows nodular structure. It shows relatively low permeability. In general it is moderately compacted. The cementing materials may be argillaceous.

Mudstone found in Labanakhya Charra Section was organic rich. Mudstone with carbonaceous matter was found in Barabkund Section.

Fig (4.1.1.0): Photograph shows mudstone with nodular structure which is the typical characteristics of Unit-A (L.C)

Fig (4.1.1.1): Photograph shows mudstone with carbonaceous matter within Unit-A at Barabkund section.

4.1.2: Silty Shale

Mainly Silty Shale is dark gray colored, occasionally it shows dark brown color. It is mainly composed of fine grained clay and silt sized particles. It is mostly laminated, occasionally it is thinly laminated. It also shows wavy bedding and lenticular bedding, found in Barabkund Section. It shows relatively low permeability. In general, it is moderately compacted. Cementing materials may be argillaceous.

Biogenic Activity as burrows was found in Silty Shale in Zeorgory Charra Section. Iron conclusion in Silty Shale was also found in this section.

Mudcracks in Silty Shale was observed in Barabkund Section.

Fig (4.1.2): Photograph shows silty shale which is the major rock type of Unit-B

4.1.3: Sandy Shale

Sandy Shale is dominantly grayish colored, but yellowish brown colored sandy shale was also found in Georgory Charra Section. It is mainly composed of fine grained sand and silt sized particles. It is mainly parallel laminated; occasionally it shows micro-cross lamination. But it also shows ripple lamination, flaser and lenticular bedding and wavy bedding, found in both Labanakhya Charra Section and Georgory Charra Section. It shows relatively moderate permeability. In general, it is moderately compacted. Both ferrogenous and argillaceous cementing materials may be present.

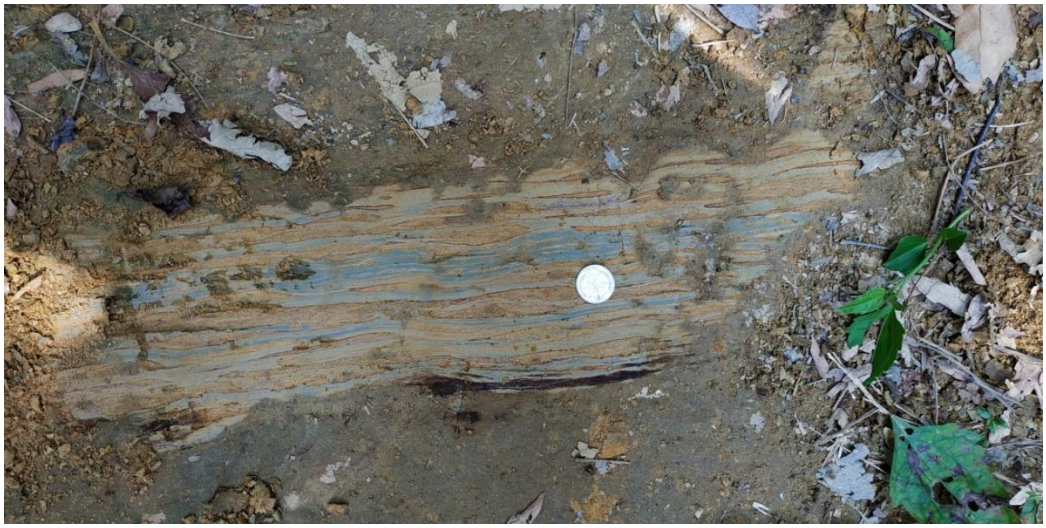

Fig (4.1.3): Photograph shows lenticular bedding in sandy shale of Unit-C at BRC section

4.1.4: Yellowish Brown Sandstone

It is yellowish brown colored. It is dominantly composed of fine to medium grained sands. It mainly shows massive structure, but occasionally it shows internal lamination. It shows relatively high permeability. It is moderately compacted. Cementing materials may be ferrogenous. Significant amount of mica is also present in this sandstone.

Fig (4.1.4): Photograph showing yellowish brown massive sandstone at Z.C section.

4.1.5: Gray Sandstone

It is gray colored. It is composed of fine grained sands. It mainly shows flaser structure. But it also shows trough cross lamination and ripple lamination. It shows relatively high permeability. It is hard and compact. Cementing materials may be siliceous.

4.1.6: Cross Laminated Sandstone

This sandstone is yellowish brown colored. It is composed of medium grained sands. It dominantly shows cross lamination. It shows relatively high permeability. It is loosely compacted. Cementing materials may be ferrogenous.

Fig (4.1.6): Photograph shows yellowish brown cross laminated medium grained sandstone (Unit-D)

4.1.7: Variegated sandstone

It shows various different colors. It is composed of coarse grained sandstone. It is mainly thinly laminated, but also shows trough cross lamination. It shows relatively high permeability. It is loosely compacted. Cementing materials may be ferrogenous.

Fig (4.1.7): Photograph shows trough cross lamination within medium- coarse grained variegated color sandstone (Unit-E)

4.1.8: Thin Bedded Sandstone

It is brown colored. It is composed of fine grained sands. It is dominantly thinly bedded, But it occasionally shows parallel lamination (L.C Section). It also shows ripple lamination, found in Z.C Section. It shows relatively moderate permeability. It is moderately compacted.

Biogenic Activity as impressions of leaf was also found in this sandstone in Barabkund Section.

Fig (4.1.8): Photograph shows parallel lamination in thin bedded sandstone of Unit-B at L.C section.

4.1.9: Massive Sandstone

This sandstone is yellow colored. It is dominantly composed of fine sands. It mainly shows massive structure, but occasionally it shows parallel lamination. It shows relatively moderate permeability. It is moderately compacted. Cementing materials may be ferrogenous. Significant amount of mica is present.

Very thick bedded, massive sandstone was found in Zeorgory Charra Section.

Fig (4.1.9): Photograph shows a very thick bedded fine grained massive sandstone member of Unit-C observed at Z.C section.

4.2.0: Calcareous Sandstone

It is gray colored. It is dominantly composed of fine grain sands. It generally exhibits massive structure. It is relatively poor permeability. It is highly compacted. It also shows strong reaction with HCl.

4.2.1: Conglomerate

It is dark brown colored. It is dominantly composed of fine grained matrix as opposed to the clasts. It is massive in structure. It shows relatively poor permeability. It is moderately compacted.

Fig (4.2.1): Photograph shows marix supported conglomerate at Barabkund Section.

4.2: 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. Sedimentary structures that are produced shortly after deposition and as a result of compaction and desiccation are called penecontemporaneous sedimentary structures. Examples include mud cracks. Still other sedimentary structures like concretions form well after deposition and penecontemporaneous modification; these are known as secondary structures. Finally, others like organic burrows and tracks, though they may in fact be primary, penecontemporaneous, or even secondary, may be grouped as a fourth category—organic sedimentary structures (Wikipedia).

Based on our field observation we found **primary sedimentary structures** such as Lenticular Bedding, Nodular Structure, Cross Bedding, Parallel Lamination, Wavy Bedding, Trough Cross Bedding etc. We also observed some **penecontemporaneous** and **secondary structures** such as

mud cracks and **iron concretions**. Finally we found some **organic sedimentary structures** such as **burrows** and **plant impressions**.

The Primary Structures that we observed in our field work are described below:

4.2.1: 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 (Wikipedia).

We found this structure only in Mudstone in every section (Fig 4.1.1.0).

4.2.2: Wavy Bedding

Wavy bedding is a form of heterolithic sediment characterized by interbedded rippled sands and mud layers.

In both Silty Shale and Sandy Shale wavy bedding was found. We observed this structure in Labanakhya Charra Section, Zeorzory Charra Section and Barabkund Section.

Fig (4.2.2): Lower part of the photograph shows wavy bedding and upper part showing lenticular bedding observed in Silty Shale of Unit B at B.R.C section

4.2.3: 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 (Wikipedia).

We observed this structure in Sandy Shale and Silty Shale. This structure was visible in Labanakhya Charra Section, Zeorzory Charra Section and Barabkund Section (Fig 4.2.2).

4.2.4: Parallel Lamination

In this structure lamina are essentially parallel to each other. Parallel lamination is produced by less severe or shorter lived fluctuations in sedimentation condition.

We observed this structure in both Sandy Shale and Thin Bedded Sandstone. This structure was found in Labanakhya Charra Section and Bariadhala Section (Fig 4.1.8).

4.2.5: Ripple Cross Lamination

Ripple cross lamination forms when deposition takes place very rapidly during migration of current or wave ripples. A series of cross laminae are produce by superimposing migration ripples (Wikipedia).

This structure was found in Sandy Shale, Gray Sandstone and Thin Bedded Sandstone. We observed this structure in Labanakhya Charra Section, Zeorzory Charra Section and Bariadhala Section.

4.2.6: Massive Structure

Rocks are called massive when beds are homogeneous and lacking in internal structure.

We found this structure in Massive Sandstone and Yellowish Brown Sandstone. We observed this structure in both Zeorzory Charra Section and Bariadhala Section.

4.2.7: 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 (Wikipedia).

We observed this structure in Labanakhya Charra Section, Barabkund Section and Bariadhala Section.

Fig (4.2.7): Photograph shows flaser bedding within sand ripples in Unit B of Bariyadhala section.

4.2.8: Trough Cross Lamination

Trough cross lamination consists of cross bedded units in which one or both bounding surfaces are curved.

We found this structure in Gray Sandstone. We also found this structure in Variegated Sandstone which was found in Bariadhala Section.

4.2.9: Thin Lamination

We mainly observed thin lamination in Variegated Sandstone found in Bariadhala Section. Occasionally thin lamination was found in Silty Shale.

Besides these structures we found some structures in very minor scale. These are Micro-cross lamination occasionally found in Sandy Shale.

Penecontemporaneous Sedimentary Structures that we found are given below:

4.3.0: Mud Cracks

Mud cracks (also known as desiccation cracks, mud cracks or cracked mud) are sedimentary structures formed as muddy sediment dries and contracts. Crack formation also occurs in clay-bearing soils as a result of a reduction in water content (Wikipedia).

We found Mud Cracks in Silty Shale at Barabkund Section.

Fig (4.3.0): Photograph showing mudcracks in silty shale found in Barabkund section

Secondary Sedimentary Structures that we found are given below:

4.3.1: Iron Concretion

A concretion is a hard, compact mass of matter formed by the precipitation of mineral cement within the spaces between particles, and is found in sedimentary rock or soil.

We found Iron Concretions within interbedded sandstone at Barabkund Section.

Fig (4.3.1): Photograph shows iron concretions within interbedded sandstone of Unit C at BRC section.

4.3.2: 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 lense shape clay galls, generally oriented parallel to the bedding.

We observed this structure in Bariadhala Section.

Fig (4.3.2): Photograph shows presence of clay gall in Unit E in Bariadhala Section.

Organic Sedimentary Structures that we observed in our field work are described below:

4.3.3: Plant Impression

We observed impressions of plant in Thin Bedded Fine Grained Sandstone at Barabkund Section.

Fig (4.3.3): Photograph shows a plant impression in thin bedded fine-grained sandstone of Unit B at Barabkund section.

4.3.4: 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.

We observed burrows mainly in Silty Shale in Barabkund Section. We also observed burrows occasionally in Mudstone.

Fig (4.3.4): Photograph shows thin lamination and lenticular sedi. structure with bioturbation in the silty shale of Unit B at Barabkund section.

Chapter Five: Stratigraphy

Stratigraphy is a branch of geology concerned with the study of rock layers (strata) and layering (stratification). A common goal of stratigraphic studies is the subdivision of a sequence of rock strata into mapable units, determining the time relationships that are involved and correlating units of the sequence, or the entire sequence, with rock strata elsewhere.

Based on our field observation we found five litho-stratigraphic units. These units from Oldest to Youngest are Unit-A (Mudstone), Unit-B (Shale), Unit-C (Alternation of Sandstone and Shale), Unit-D (Yellowish Brown Sandstone), and Unit-E (Variegated Sandstone). In some cases contact between two units was distinguished.

Fig (5.1): Photograph shows the possible contact between Unit A and B along the red line at the Z.C section.

Following is the description of the major rock types of these units and of the depositional environment:

Possible age	Stratigraphic Unit	Major Rock Types	Description	Approximate Thickness	Depositional Environment
Youngest ↑	Unit-E	Variegated Sandstone	Exhibiting different colors, composed of coarse grained sands, showing mainly thin lamination but occasionally trough cross lamination.	2400+	Fluvial
	Unit-D	Yellowish Brown Sandstone	Yellowish Brown colored, composed of medium grained sands, dominantly shows cross lamination.	3400+	Fluvial
	Unit-C	Alternation of Sandstone and Shale	Thin Bedded Sandstone with Shale	2400+	Deltaic
	Unit-B	Shale	Silty and Sandy Shale with Calcareous Sst bent and thin to medium bedded Sst. In the BK section, in the upper part we saw evidence of Conglomerate.	1400+	Deltaic to Shallow Marine
↓ Oldest	Unit-A	Mudstone	Gray colored, composed of clay and silt sized particles, shows nodular structure.	Bottom not found	Shallow Marine

Chapter Six: Structure Analysis

6.1: Major Structures

A. Fold

The field observation suggests that Sitakund Anticline is a major foldbelt. Based on our field observation it is assumed that Sitakund Anticline is an Asymmetrical Overturned Anticline.

Evidence for Fold:

1. Based on our observation Eastern Flank was gentle and we found overturned bed in the Western Flank which was much steeper.
2. Our observation suggests that the oldest rock unit Mudstone was in the center of the anticline.
3. Our schematic, regional and Bariadhala cross-section suggests that Sitakund is a major asymmetrical overturned anticline.

B. Fault

According to our field observation we found four major reverse faults in Sitakund area.

1. **Topographical Change**: Our observation suggests that first possible fault might be in the break in topography, where we observed stratigraphic missing of units below unit-A.

2. **Gas Seepage**: Second fault might be along the line of gas seepages. We observed gas seepages in Labankhya Charra Section and Barabkund Section, which is undoubtedly one of the interesting features in these areas. Our observation suggests that, Gas Seepage is an evidence of a zone of weakness (possibly fault).

3. **Fault Escarpment**: Another fault might be along the line where we found sharp fault escarpments, running almost in N-S direction. Fault escarpment is possibly related to fault.

4. **Stratigraphic Missing**: Based on our observation, another fault may be present, where we found stratigraphic missing of unit-E after unit-D; rather we found repetition of unit-C after unit-D. This provides clear evidence that a possible fault is present after unit-D.

Fig(6.1.1): Photograph shows gas seepage at the Barabkund temple. Such feature can be linked with geological fault.

Fig (6.1.2): Photograph shows sharp escarpment, running almost N-S direction. Such feature is possibly related to a fault.

Evidence for fault:

1. Topographic evidence: Abrupt change in lithology in the studied area. Varieties of Shale observed in the Western Flank whereas Sandstone is observed in the Eastern Block.
2. Anomalous Attitude: We observed anomalous attitude in Bariadhala Section.

3. Fault Escarpment: Fault escarpment observed in the Barabkund section exhibits another evidence of possible faulting.

6.2: Minor Structure

A. Joint

In geology, a joint is a fracture dividing rock into two sections that haven't moved away from each other. We observed several types of joint in the studied area. These are described below:

1. **Oblique Joint:** In Labanakhya Charra Section we observed a joint in Labanakhya Water Fall, which may be possibly an oblique joint.

Fig (6.2.1): Photograph shows a possible oblique joint at the Labanakhya Water fall.

We also observed possible Dip joint and Vertical Joint in Labanakhya Charra Section.

B. Fold

Folds are undulation or bands or waves in the rock of the earth surface.

In Zeorzory Charra Section we observed minor overturned folding.

Fig (6.2.2): Minor overturned folding at Zeorzory Charra Section.

We also observed fold in Barabkund Section.

Fig (6.2.3): Photograph shows evidence of micro-fold within Unit B of Barabkund section.

C. Unconformity

An **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 (Wikipedia).

We observed evidence of unconformity in Barabkund Section.

Fig (6.2.4): A local unconformity is observed between Unit B & C at Barabkund section.

Chapter Seven: Geologic History

Based on our field observation and Cross Section we found five Stratigraphic Unit. These are Unit-A (Mudstone), Unit-B (Shale), Unit-C (Alternation of Sandstone and Shale), Unit-D (Yellowish Brown Sandstone), and Unit-E (Variegated Sandstone). Among these units, Unit-E is the Youngest and Unit-A is the Oldest.

The major rock type of Unit-A is Mudstone. It is mainly Gray colored, composed of clay and silt sized particles, shows nodular structure.

Rock type of Unit-B is Shale. We observed Silty and Sandy Shale with Calcareous Sst bent and thin to medium bedded Sst. In the BK section, in the upper part we saw evidence of Conglomerate.

In Unit-C, we observed alternation of Sandstone and shale.

Rock type of Unit-D is mainly Yellowish Brown Sandstone. It is Yellowish Brown colored, composed of medium grained sands, dominantly shows cross lamination.

The youngest unit among all units is Unit-E. The rock type of this unit is Variegated Sandstone. It exhibits different colors, composed of coarse grained sands, showing mainly thin lamination but occasionally trough cross lamination.

By observing the color, texture, grain compaction of these rock units, it is assumed that, the depositional environment of Unit-A, Unit-B and Unit-C is Deltaic to Shallow Marine and for Unit-D and Unit-E, it is Fluvial.

We only determined the relative age of these units not the absolute age. Major tectonic structure of the area is an asymmetric anticline which is overturned. This structure formed through Indo-Burman collision during Oligocene to Miocene. (Johnson and Alam, 1991).

An interbedding Gravel Log was found in the Barabkund Section which proves that this area is tectonically active signifying that Sitakund Anticline is still uplifting.

Chapter Eight: Economic Geology

Economic Geology is concerned with earth materials that can be used for economic and/or industrial purposes. These materials include precious and base metals, non-metallic minerals, construction grade stone, petroleum minerals, coal and water. In general, the term commonly refers to metallic mineral deposits and mineral resources (Wikipedia, 2019).

Economic importance in Geological Sciences is applied only to rock material or hydrocarbons that have an economically profitable value. Bangladesh is poor in material deposits which could be beneficial to economy.

Economically Sitakund anticline and its adjoining areas are less important for economic purposes.

The gas seepages found in Labanakhya Charra Section and Barabkund Section, proves the presence of gas in Stakund area. But the economic value of these gases is poor.

Various types of Sandstone that have been observed in Bariadhala Section are mostly used for construction of road, bridges, buildings etc.

Limestone, which has been observed in the Zeorzory Charra section, is also used for construction of road, buildings, cement industry etc.

Gravel, that have been observed in the Barabkund Section is mostly used to make concrete, for road construction, for mixing with asphalt, as construction fill and in the production of construction material like concrete blocks, bricks and pipes etc.

Chapter Nine: Conclusion

The Sitakund anticline area is a hilly region with the presence of irregular topographical features and high altitude hillocks. The Sitakund anticline is situated within the eastern hillly domain which is largely known as Chittagong hill range. The studied area of Sitakund anticline is in the North West part of Chittagong District, mainly concerned with fundamental knowledge of general stratigraphy, sedimentology, structures, tectonic setting, depositional environment and economic importance.

The outcrops are generally poorly developed or already eroded out due to natural processes and anthropogenic activities. The boundary of the individual formation cannot be sharply detected because of weathered materials, vegetation. Due to short time span a reconnaissance survey have been conducted and many information are collected from field lecture and literature.

The exposed rock of the area that have been studied, are divided into five major stratigraphic units, which are Unit-A, Unit-B, Unit-C, Unit-D and Unit-E (from oldest to youngest). The major rock types of these units are Mudstone, Shale, Alternation of Sandstone and Shale, Yellowish Brown Sandstone and Variegated Sandstone. By observing the color, texture, grain compaction and structure of these rock units, it is assumed that, the depositional environment of Unit-A is Shallow Marine, depositional environment of unit-B is Deltaic to Shallow Marine, depositional environment of Unit-C is Shallow Marine and depositional environment of Unit-D and E is Fluvial.

It has been observed that Sitakund Anticline is an Asymmetrical Overturned Anticline. Based on our observation it is also assumed that western flank of this anticline is steeper and eastern flank is gentle. We also observed four major structures in the area which possibly could be Faults and also observed some minor structures such as Fold, Joint and Unconformity.

Finally, it may conclude that Sitakund Anticline area is very preferable for a Sedimentologist and a Structural Geologist, because this area offers the good exposure of sedimentary rock and excellent structural features.

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Chapter Ten: References

Abdullah, R., Yeasmin, R., Ameen, S.M.M., Khanam, F., Bari, Z., 2015, 2D Structural modeling and hydrocarbon potentiality of the Sitakund Structure, Chittagong Tripura Fold Belt(CTFB), Bengal Basin ,Bangladesh. Journal of the Geological Society of India, v.58, no. 6, p. 697-705.

Akter, S.H. (1979) Structure, stratigraphy and sedimentology of the Upper Tertiary sediments of the central part of the Sitakund Hill Range, Chittagong, Bangladesh, M.Sc., thesis, Department of Geology, University of Dhaka.

Alam, M., Alam, M.M., Curray, J.R., Chowdhury, M. L. R., Gani, M. R., 2003, An overview of the sedimentary geology of the Bengal Basin in relation to the regional tectonic framework and basin-fill history. Sedimentary Geology, v. 155, no.3, p.179-208.

Hossain, K.M. and Akter, S.H. (1983) Structural behavior of the Sitakund Hill Range, Bangladesh Jour. Geol., v.2, pp.17-27.

Johnson, S.Y., Alam, A.M.N.,1991, Sedimentation and tectonics of the Sylhet trough, Bangladesh Geological Society of America Bulletin, v. 103, no. 11, p. 1513-1527.

Khanam, F.,Rahman, M. J. J., Alam, M. M.,Abdullah, R., 2017, Facies characterization of the Surma Group (Miocene) sediment from Jalalabad Gas Field, Sylhet Trough, Bangladesh: study from cores and wireline logs. Journal of the Geological Society of India, v.89, p. 155-164.

Latif, M.A. and Hossain, M.T. (1965) Geology of the Sitakund Hill Range, Jour. Dhaka Univ. Studies, v.13, pp.7-16.

Muminullah, M. (1978) Geology of the northern part of Chittagong district, Bangaldesh, Geol. Surv. Bangladesh, v.2, 18p.

Najman, Y., Bickle, M., BouDagher-Fadel, M., Carter, A., Garzanti, E., Paul, M., Wijbrans, J., Willett, E., Oliver, G., Parrish, R., 2008, The Paleogene record of the Himalayan erosion: Bengal Basin, Bangladesh. Earth and Planetary Science Letters, v.279, no. 1, p. 1-14.

Samad, A. and Ali, S.A. (1968) Study of Geochemical parameters and reservoir properties of Miocene sediment of part of Chittagong Hill Tracts, East Pakistan ,Pak ,Jour., Ind. Res., v.11, pp.317-324.

Samad. A. and Hassan, M.P. (1982) Textural properties and heavy mineral content of Miocene sediments from Bariyadhala road section, Situkund anticline, Chittagong, Bangladesh Jour. Geol., v.1, pp.23-33.

Shamsuddin, A. H. M., Abdullah, S. K. M., 1997, Geological evolution of the Bengal Basin and its implication in hydrocarbon exploration in Bangladesh. Indian Journal of geology, v.69, no.2, p.93-121.

Rahman, M. J. J., Faulp, p., 2003a, 40Ar/39 Ar multigrain dating of detrital white mica of sandstones of Surma Group in the Sylhet Trough, Bengal Basin, Bangladesh. Sedimentary Geology, v.155, no. 3, p. 383-392.

Reimann, K.U., 1993,The Geology of Bangladesh .Berlin, Gebruder Borntraeger, p. 160.