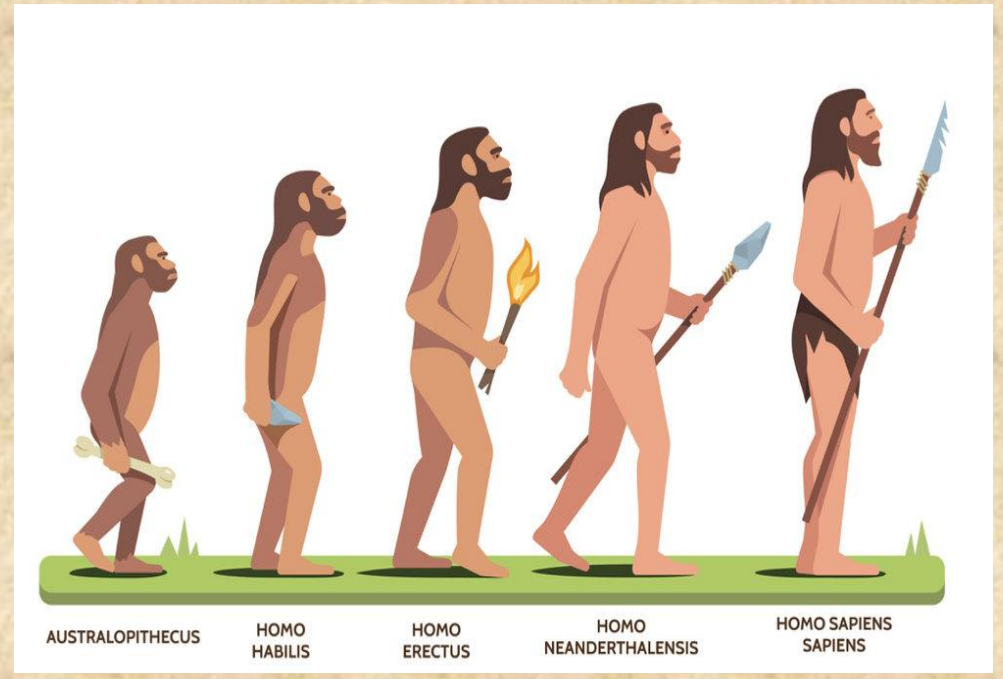
Quaternary Geology

Lecture 2

Dhiman Roy, PhD



quaternary

Course outline

- **Part-I**
  - Quaternary: Concept and Development
- **Part-II**
  - Quaternary Stratigraphy – Madhupur Area
  - Quaternary Stratigraphy – Sylhet Region
  - Quaternary Stratigraphy – Mymensingh Area
  - Quaternary Stratigraphy – Panchagarh Area
  - Quaternary Stratigraphy – Barind Tract Area
- **Part-III**
  - Late Quaternary Monsoon Climatic Episodes
  - Paleosoil and Micromorphology
  - Correlation of Quaternary Deposits

Quaternary Stratigraphy

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Age	Stratigraphic units	Lithology	Notes
Late Pleistocene–Holocene	Chandina Formation Dhamrai Formation Unclassified deposits	Upward fining, grey micaceous, medium and coarse sand to silt with organic mud and peat.	Forms major aquifers beneath recent floodplains. Probably <150 m thick.
Lower Pleistocene	Madhupur Clay Barind Clay	Tough, red-brown to grey, silty-clay; residual deposits; kaolinite and iron oxide.	Often absent beneath Holocene floodplains. Thickness 6 to 60 m.
Plio-Pleistocene	Dupi Tila Formation Dihing Formation	Yellowish-brown to light grey, medium and coarse sand to clay; very weakly consolidated; depleted in mica and organic matter.	Forms major aquifers beneath the terraces and hills, and deeper aquifers beneath the Holocene floodplains. Hundreds to thousands of metres thick
Tertiary	Tipam Group	Yellowish-brown, weakly consolidated sandstone and mudstone.	Minor aquifers in hills
	Surma Series	Consolidated sandstone and shale	No significant aquifers
	Barail Series	Consolidated sandstone and shale	
	Jaintia Group	Shale, limestone and sandstone	
Mesozoic	Sylhet Traps	Basalt, shale and sandstone	

After Alam et al. (1990), Khan (1991) and DPHE (1999)

Talk outline

- Introduction
- Stratigraphy
  - Madhupur Area
  - Lalmai Hills Area
  - Barind Area
  - Chalanbil Area
  - Dahagam-Panchagarh Area
  - Jaintiapur-Bholagonj Area
- Depositional Environment: Gravel Bed
- Economic Importance of Quaternary

Introduction?

- The Ganges-Brahmaputra delta in the north-eastern comer of Indian subcontinent is the largest delta with one of the thickest sedimentary sequence in the present world where the Tertiary Quaternary sedimentary column is more than 20 km thick.

- The Neogene stratigraphic units of the area are diachronic in nature (Imam and Shaw, 1985).

- The Bengal Basin is mostly covered with Quaternary sediments. Deltaic flood plain with some Pleistocene terraces constitute the major part of the basin.

Introduction?

- A number of these Pleistocene terraces extends inside the territory of neighboring India.

- The network of the Ganges Brahmaputra river systems are responsible for the deposition of this thick sedimentary sequence.

- These two mighty rivers are originated from the Himalayas and discharge into the- Bay of Bengal through Bangladesh for a considerable geological time.

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- The so-called Madhupur Clay or reddish-brown deposits which makes the beautiful scenery of the Lalmai hills, Madhupur and Barind tracts attracted the general attention of the geologists as early as nineteen fifty's when Morgan and McIntire (1956) published a report at the Louisiana State University, after their reconnaissance survey over the Bengal basin.

- Afterwards, Islam (1974), Alam and Khan (1980), Hassan (1986) studied the Madhupur Clay with the similar approach as was shown by Morgan and McIntire in 1959.

- Bakr (1977) has introduced a new lithostratigaphic unit name Chandina Formation for the Holocene deposits exposed around the township of Chandina in Comilla district.

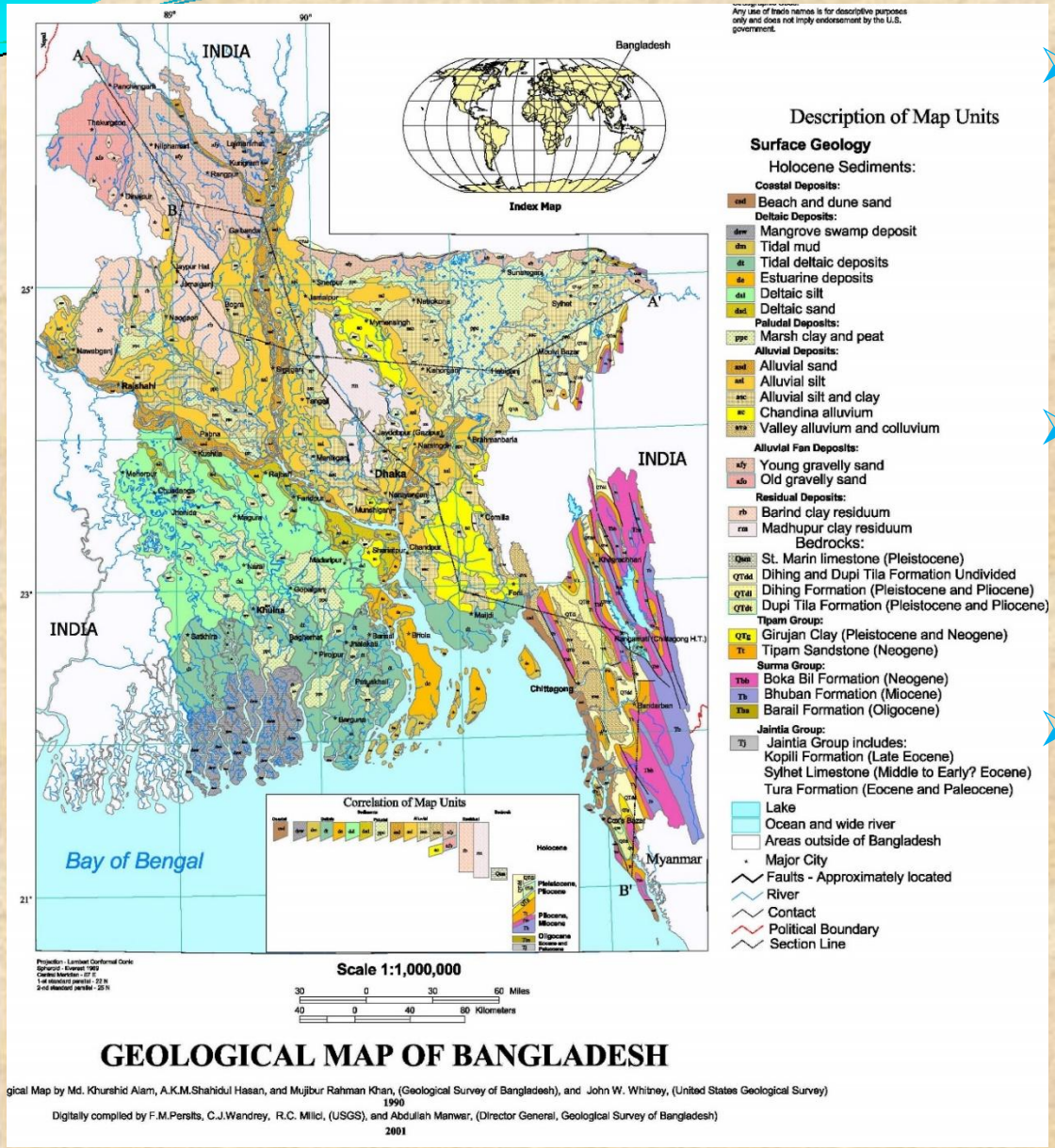
Cont'd……

- Much more detail investigations of the Quaternary deposits exposed in the Barind, Chalanbil, Panchagarh, Dahagram-Angarpota, Madhupur, Lalmai, Jaintiapur, areas and also St. Martin's, Kutubdia, Maiskhali Islands were carried out after nineteen ninety's (Akhter and Hoque, 1993; Monsur, 1990; Monsur and Hossain, 1992; Monsur and Paepe, 1992, 1993, 1994; Monsur and Kamal, 1994; Monsur and Paepe, 1994; Monsur, 1994; Monsur, 1995; Morshed, 1994; Saha, 1994).

- Detail stratigraphical, sedimentological, palaeomagnetical, pedological, micromorphological studies were carried out in order to establish a systematic Quaternary stratigraphy and to infer a depositional environment.

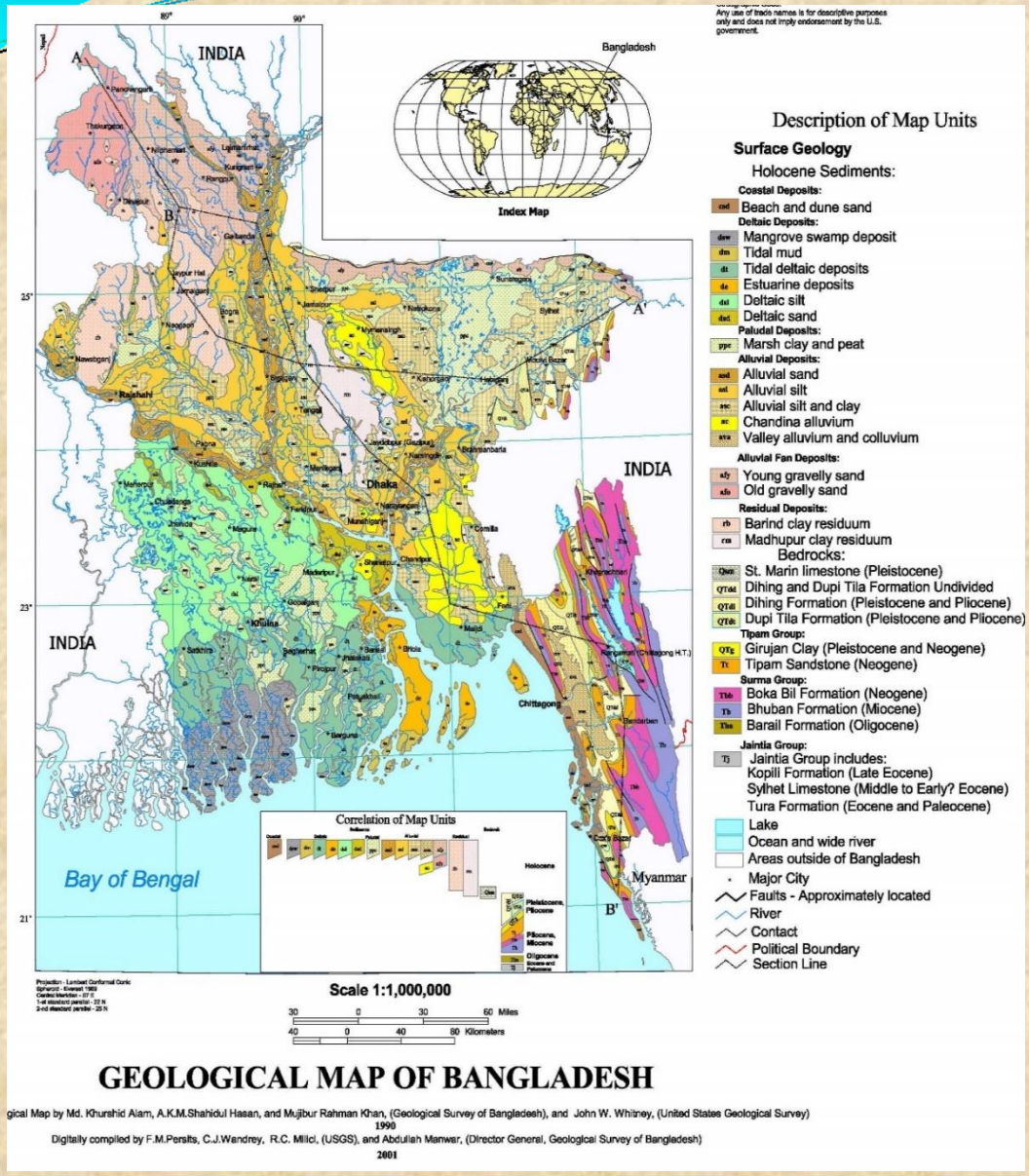
- A systematic studies of coastal plains of onshore and near shore islands revealed a cyclicity of Holocene sea-level rise for clear understanding, the stratigraphy of different geomorphic units of the Bengal basin are discussed separately in the following texts.

Quaternary Stratigraphy : Madhupur Area



- The Madhupur area has been considered as an area which comprises the Vawal and Madhupur Garghs.
- This area of about 4058 sq.km., extends in Dhaka, Mymensingh and Tangail districts.
- The so-called Madhupur Clay or reddish brown deposits are exposed on some north-south trending elongated flat landmasses abruptly elevated from the surrounding floodplains.

Quaternary Stratigraphy : Madhupur Area



- In the Madhupur area, Quaternary deposits are subdivided into two Formations (Monsur and Paepe, 1994 Monsur, 1995) and are called :
- i) **Madhupur Clay and Sand Formation** (lower unit), represented by reddish-brown sand, sandy-clay and clay; and
- ii) **Basabo silty-clay Formation** (upper unit), represented by yellowish brown to bluish-grey sand to clay.

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Stratigraphy of Madhupur Area

Chronostratigraphy: Series	Chronostratigraphy: Sub-Series	Formation	Member	Bed	Lithologic description	Thickness (m)
HOLOCENE	Sub-Atlantic	Basabo Silty-clay	Matuail Clay	Silty clay	Pale olive (5Y 6/4) very sticky silty clay with modern soil on top. Unconformity	5
	Sub-Boreal			Clayey silt	Light yellowish brown (10YR 6/4) very sticky clayey silt, containing plenty of plant roots and iron concretions. Unconformity	
	Atlantic		Gulshan Sand	Silty clay	Yellowish red silty clay. Unconformity	It varies
	Boreal			Clayey silt	Pale yellow (5Y 7/3) clayey silt, containing wood fragments, plant roots and iron concretions. Unconformity	
	Pre-Boreal			Sand	Light bluish grey (5B 7/1) sand-silt-clay to sand. It contains roots, wood fragments and Fe-concretions Unconformity	
PLEISTOCENE	Middle	Madhupur Clay and Sand	Kalsi Beds	1	Pale yellowish brown with light brown spotted sandy clay (contains volcanis ash?) Unconformity	2
	Lower			2	Yellowish brown very sticky silty clay, containing iron concretions Unconformity	4
			Dhaka Clay	M2-1	Red (2.5 YR 4/6) with reddish yellow (7.5 YR 6/6) reduction spots. It is highly weathered and powdery. It contains Fe-concretions, pipe-stems, calcareous nodules, plant roots, micas and manganese spots. Unconformity	5
			Mirpur Silty-clay	M2-2	Light brown (5YR 4/6) sandy clay to clayey sand with moderate reddish brown (10R 4/6) spots, containing iron concretions, pipe stems, plant roots and Mn- spots. Unconformity	4
			Bhaluka Sand	M2-3	Pale yellowish brown (10R 6/2) silty-sand to sand. It is highly micaceous and cross bedded, contains Mn-spots. Micas are biotitic and highly oxidized. It contains some intraformational clay layers. Unconformity	4
PLIOCENE		Dupi Tila			Quartz-chalcedony Gravel Bed Oxidized sands with intraformational clay beds. It contins large silicified woods	

- The lower boundary of the Madhupur Formation is represented by the Quartz-chalcedony Gravel layer which is called **Comilla Quartz-chalcedony Gravel Bed.**
- The thickness of this Formation is about 14 to 20m.
- The Madhupur Formation has further been subdivided into three Members (lower subunits) and two Beds (upper subunit) based on the presence of two palaeosol horizons.

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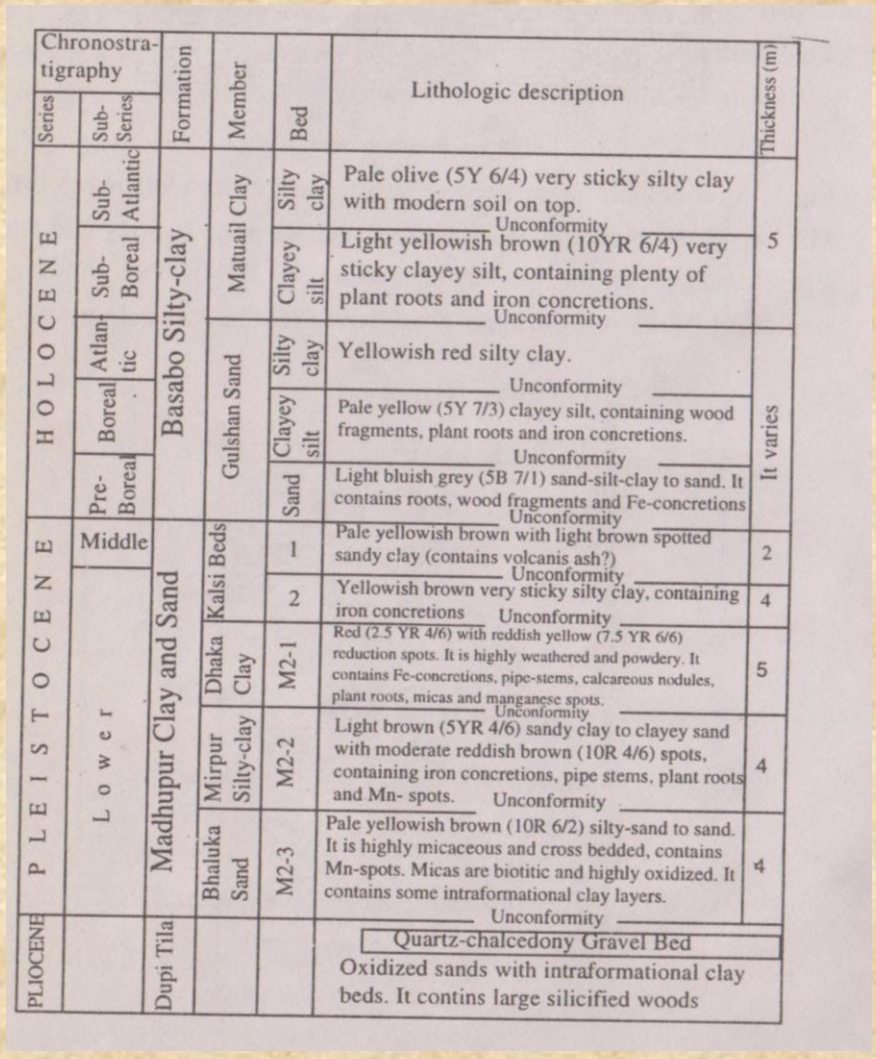
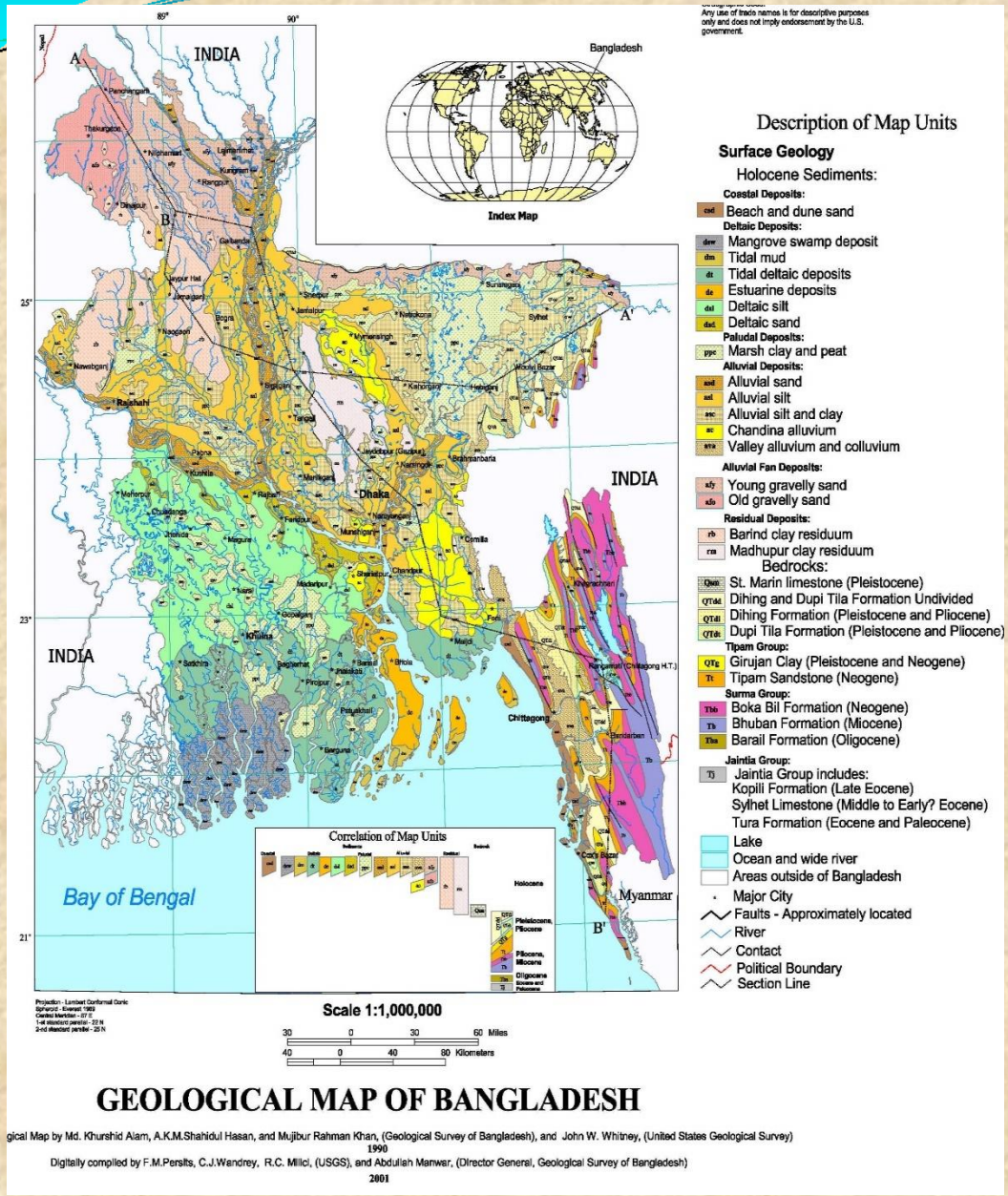
Stratigraphy of Madhupur Area



Chronostratigraphy: Series	Chronostratigraphy: Sub-Series	Formation	Member	Bed	Lithologic description	Thickness (m)
HOLOCENE	Sub-Atlantic	Basabo Silty-clay	Matuail Clay	Silty clay	Pale olive (5Y 6/4) very sticky silty clay with modern soil on top. Unconformity	5
	Sub-Boreal			Clayey silt	Light yellowish brown (10YR 6/4) very sticky clayey silt, containing plenty of plant roots and iron concretions. Unconformity	
	Atlantic		Gulshan Sand	Silty clay	Yellowish red silty clay. Unconformity	It varies
	Boreal			Clayey silt	Pale yellow (5Y 7/3) clayey silt, containing wood fragments, plant roots and iron concretions. Unconformity	
	Pre-Boreal			Sand	Light bluish grey (5B 7/1) sand-silt-clay to sand. It contains roots, wood fragments and Fe-concretions Unconformity	
PLEISTOCENE	Middle	Madhupur Clay and Sand	Kalsi Beds	1	Pale yellowish brown with light brown spotted sandy clay (contains volcanis ash?) Unconformity	2
				2	Yellowish brown very sticky silty clay, containing iron concretions Unconformity	4
	Lower		Dhaka Clay	M2-1	Red (2.5 YR 4/6) with reddish yellow (7.5 YR 6/6) reduction spots. It is highly weathered and powdery. It contains Fe-concretions, pipe-stems, calcareous nodules, plant roots, micas and manganese spots. Unconformity	5
			Mirpur Silty-clay	M2-2	Light brown (5YR 4/6) sandy clay to clayey sand with moderate reddish brown (10R 4/6) spots, containing iron concretions, pipe stems, plant roots and Mn- spots. Unconformity	4
			Bhaluka Sand	M2-3	Pale yellowish brown (10R 6/2) silty-sand to sand. It is highly micaceous and cross bedded, contains Mn-spots. Micas are biotitic and highly oxidized. It contains some intraformational clay layers. Unconformity	4
PLIOCENE		Dupi Tila			Quartz-chalcedony Gravel Bed	
					Oxidized sands with intraformational clay beds. It contins large silicified woods	

- The Members are called **Bhaluka Sand Member**, **Mirpur Silty-clay Member** and **Dhaka Clay Member.**
- **The lower and upper Beds of this** Formation are called **Kalsi Beds**.
- Similarly, the Basab Formation has also been subdivided into two Members: **Gulshan Sand Member** and **Matuail Clay Member**.

Quaternary Stratigraphy : Lalmai Hills Area



- The reddish brown deposits are widely exposed in the Lalmai hills area.
- The Lalmai hills are situated in the Comilla district of Bangladesh.
- The Lalmai hills represent a north-south elongated low hill range of about 16 km long and about 2-3 km wide.
- The Lalmai hills area lies between the latitudes 23 20 N to 23'30'N and longitudes 91°05'E to 91 °10’E.

Quaternary Stratigraphy : Lalmai Hills Area

- It covers an area of about 33 sq. km. The hill range runs through the middle of Comilla district.
- The average height of the hills is about 12 meters but some peaks rise up to about 40 meters or more.
- Most of the hill tops are covered with reddish-brown soil which makes a beautiful scenery of the hill range.
- Some of the hill tops represent table surfaces and these table surfaces are separated from each other by deeply incised valleys.
- The northern part of the hill range is locally known as **Mainamati,** which merely echoes the memory of king Govinda Chandra's mother Mainamati, while the southern part is known as Lalmai or **'Red Hill '** from the red colour of soil (Alam and Khan, 1980).
- In geological and gcomorphological view point, the area in this discussion will be called as **Lalmai Hill Range.**

Cont'd……

- The reddish brown deposits exposed in the Lalmai Hill area are grouped together and are called **Madhupur Clay and Sand Formation.**
- The reddish brown deposits exposed in the Lalmai Hill area is the extension of the reddish brown deposits of the Madhupur area.
- Sometimes, these deposits maintain the subsurface lithologic continuity.
- Sometimes, this Formation had completely been eroded away by Late Pleistocene and Early Holocene erosional activities.
- Hence, the nomenclature **"Madhupur Clay"** which was introduced by Morgan and McIntire (1959) and its modification **"Madhupur Clay and Sand Formation"** (Monsur, 1994) were restored and were being extended to the Lalmai Hill area and was called as **"Madhupur Clay and Sand Formation".**

Cont'd……

- The lower boundary of this Formation is defined by the **Comilla Quartzchalcedony Gravel Bed** (Monsur, 1994).

- The maximum exposed thickness has been recorded at BDR Camp section at Cotbari, Comilla and is about 15m.

- At Uttarkhan near Dhaka city the borehole data shows the highest thickness of this Formation and it is about 50m.

- This Formation has been subdivided into the following subunits:
  i) the upper clay subunit
  ii) the middle clayey-sand subunit
  iii) the lower sand subunit

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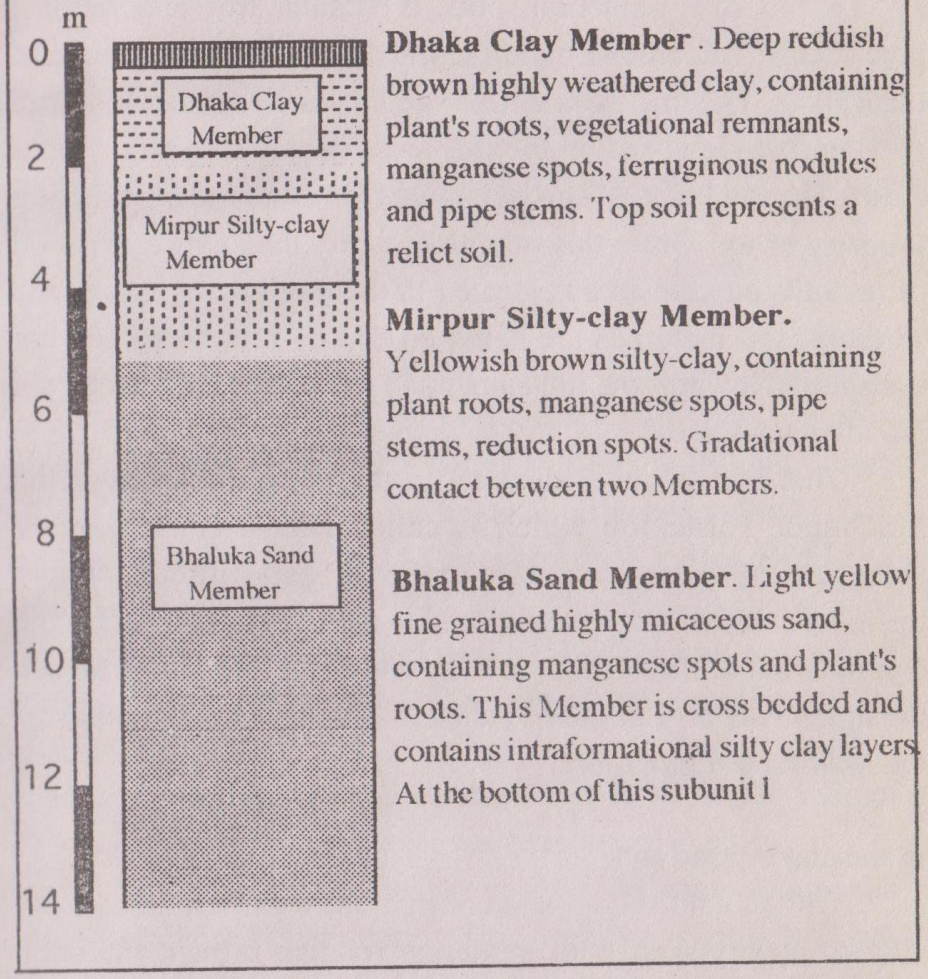
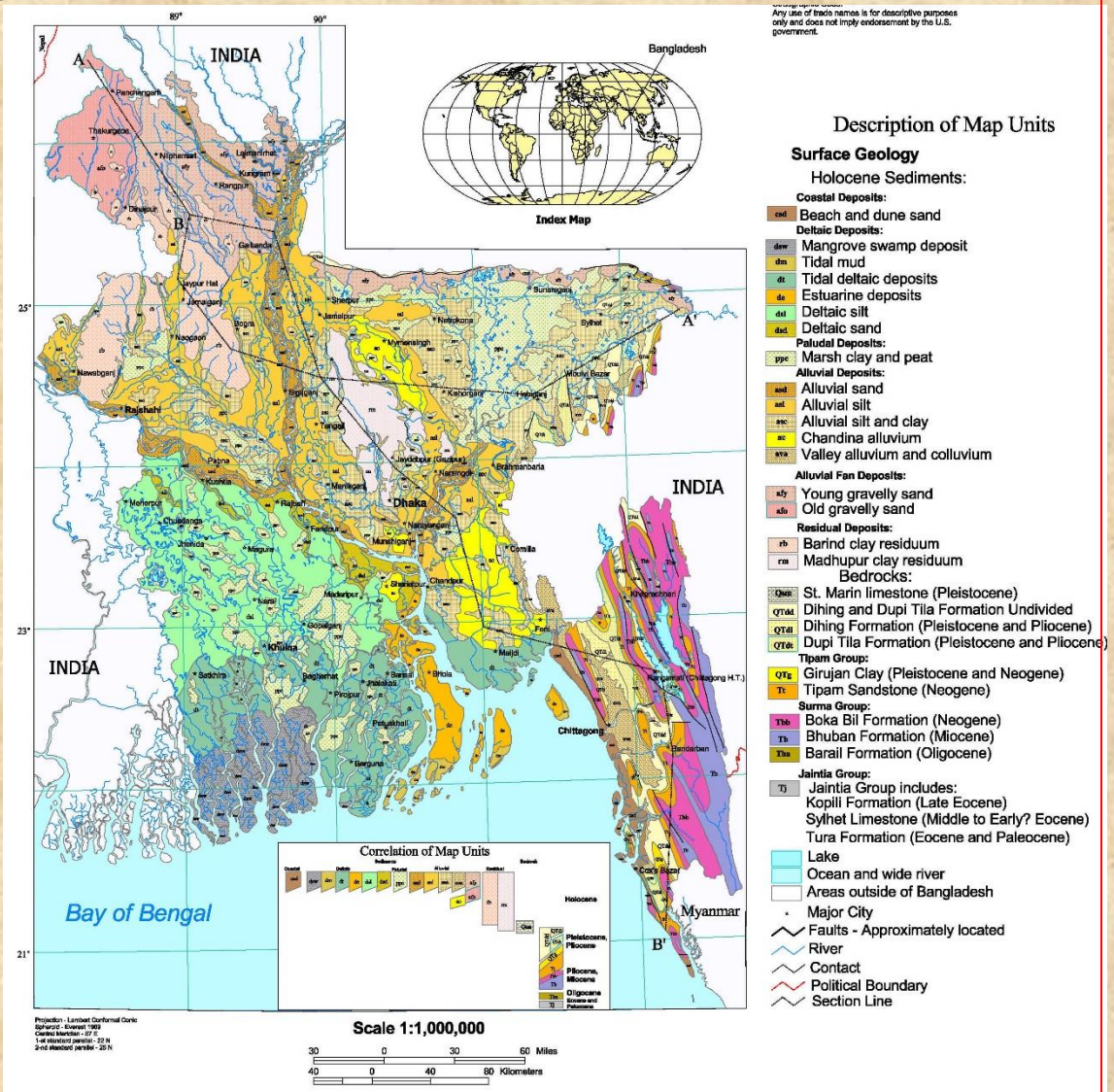


Fig.6 : Stratigraphic cross section of the hillock at the western side of the BDR camp staff quarter, Cotbari, Lalmai, Comilla.

Quaternary Stratigraphy : Barind Area



- The Barind area falls in the central part of north Bengal and covers an area of about 7680 sq.km.
- The area comprises about six north-south elongated isolated exposures of reddish brown deposits.
- Previously, the reddish-brown deposits exposed in the Barind area were also called Madhupur Clay (Morgan and McIntire, 1959), Alam and Khan (1980), Islam (1974).

Quaternary Stratigraphy : Barind Area

- The Barind and Madhupur area are quite apart from each other and there is no lithologic continuity.

- Hence, the Quaternary deposits exposed in the Barind area are considered separately since Barind tract is a different geomorphic unit.

- However, the Quaternary deposits exposed in the Barind area are subdivided into two broad units:
- i) **Barind Clay and Sand Formation** (Monsur and Paepe,1992), represented by deep reddish-brown, highly oxidized and weathered clay silty-clay and sand with ferruginous concretions, calcareous nodules, plant roots, pipe stems and manganese spots; and
- ii) **Rohonpur Silty-clay Formation,** represented by yellowish grey, silty-clay to clay with organic matter and plant roots.

Cont'd.....

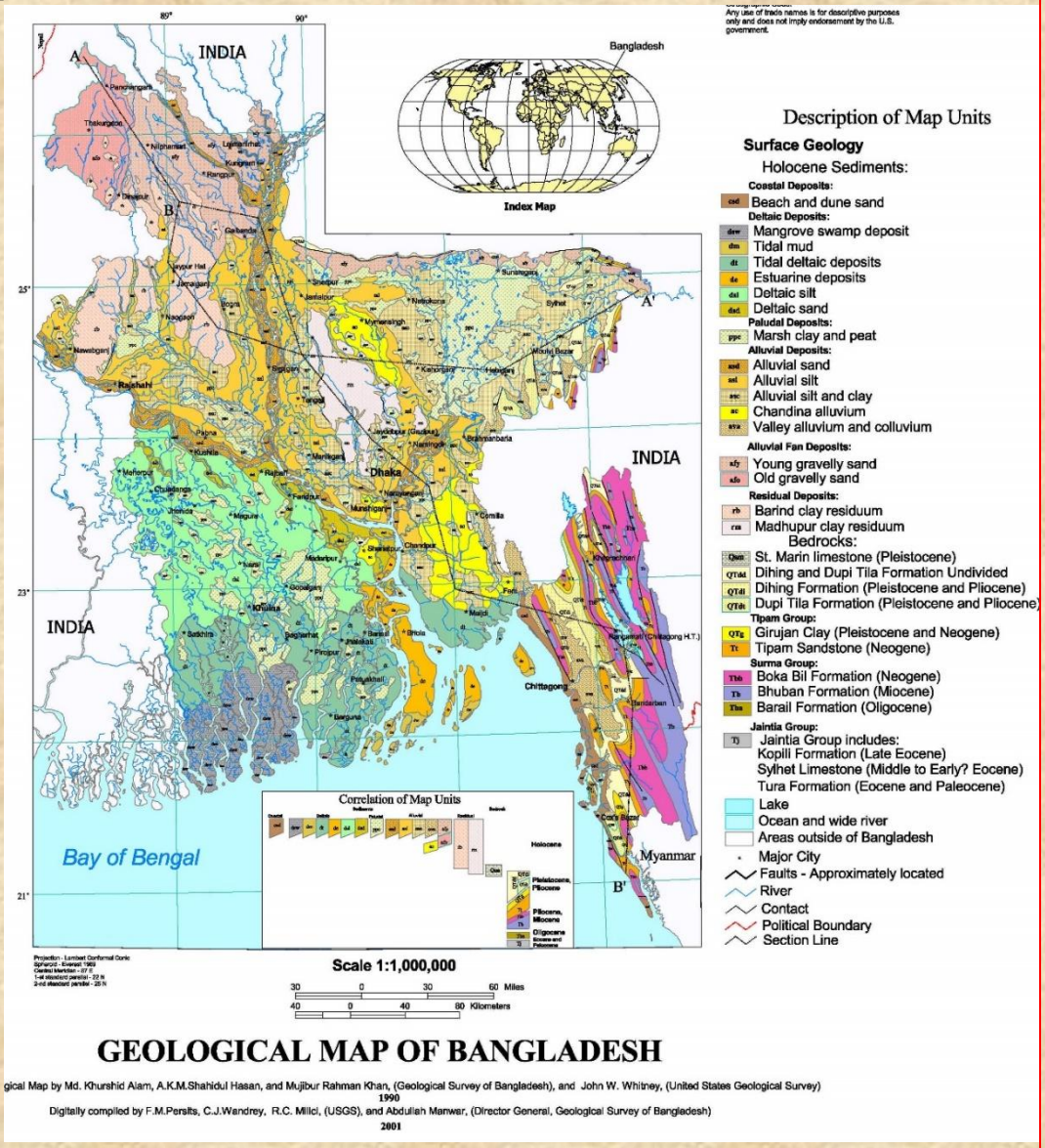
Table 2: Stratigraphic table for the Barind area.

Chronostratigraphy: Series	Chronostratigraphy: Sub-Series	Formation	Member	Bed	Lithologic description	Thickness (m)
HOLOCENE	Sub-Atlantic	Rohonpur Silty-clay		1	Light grey silt, containing ferruginous and calcareous nodules and micas	4 to 10
					Unconformity	
	Sub-Boreal			2	Geyish-brown clayey-silt, containing micas and mangabese spots	
					Unconformity	
	Atlantic			3	Olive-brown clayey silt, contaioning micas	
					Unconformity	
	Boreal			4	Light olive brown silty clay	
					Unconformity	
	Pre-Boreal			5	Olive brown silty clay, containing micas and ferruginous nodules	
					Unconformity	
PLEISTOCENE	Lower	Barind Clay and Sand		Gouripur	Yellowish brown silty clay to sand-silt-clay, containing iron concretions	4
					Unconformity	
			Sherpur Clay		Strong brown (7.5YR 4/6) with very pale brown (10YR 8/4) reduction spotted clayey silt. It contains Fe-concretions, pipe-stems, calcareous nodules, plant roots, micas and manganese spots.	3
					Unconformity	
			Nachole Silty-clay		Brownish yellow (10YR 6/8) with pale brown reduction spotted sand-silt-clay. It contains Fe-concretions, pipe-stems, plant roots, micas and manganese spots.	5
					Unconformity	
			Gujorghat Sand		Yellowish brown (10YR 5/8) silty-sand to sand. It is highly micaceous and contains manganese spots. Micas are biotitic and highly oxidized. This sand is cross bedded.	4
					Unconformity	
PLIOCENE		Dupi Tila			Quartz-chalcedony Gravel Bed	
					Oxidized sands with intraformational clay beds. It contins large silicified woods	

Cont'd……

- The Barind Formation has further been subdivided into three Members (lower subunits) and one Bed (upper subunit) based on the presence of two palaeosol horizons.
- The Members are called **Gujorghat Sand Member** (Lower Member, **R2-3), Nachole Silty-clay Member** (middle Member, **R2-2)** and **Sherpur Clay Member** (upper Member, M2-1).
- The upper Bed of this Formation is called **Gouripur Sand-silt-clay Bed.**
- Similarly, the Rohonpur Formation has also been subdivided into five subunits based on the presence of four palaeosol horizons (H).
- The presence of buried soil horizons represent the Boundary Stratotype.

Quaternary Stratigraphy : Chalanbil Area



- The famous Chalanbil means a lake or marshy land in which water flows during the flood season.
- In fact, during the rainy season (monsoon time) rivers are overloaded and the surplus water flows over the flood plain of the Chalanbil towards the mighty river Jamuna (Brahmaputra).
- The Chalanbil covers an area of about 500 sq.km. Roughly, the Chalanbil is extended from the village town Singra upto the village Naogaon and Chatmahor to Bastul.

Cont'd……

- The environmental of change in Chalanbil area is quite prominent. Only about 200 years BP, the heart of the Chalanbil had never been dried up even during the peak of the dry season.
- As a result, it was a good site for gathering wild buffaloes during the dry (hot) season which created several pools and depressions.
- The wide area of Chalanbil is covered by Holocene fluvial deposits. The observation of different boreholes, pond and canal digging led to subdivide the deposits into the following units

I) the upper sticky silty-clay unit (Cl) which is called Chalanbil Silty-clay Formation (Monsur, 1993).
II) The Chalanbil Formation is underlain by the micaceous sand unit (C2) which is called Barind Formation.

- The Barind Formation is underlain by the Quartz-chalcedony Gravel layer (Comilla Gravel Bed) of Dupi Tila Formation of Pliocene age.

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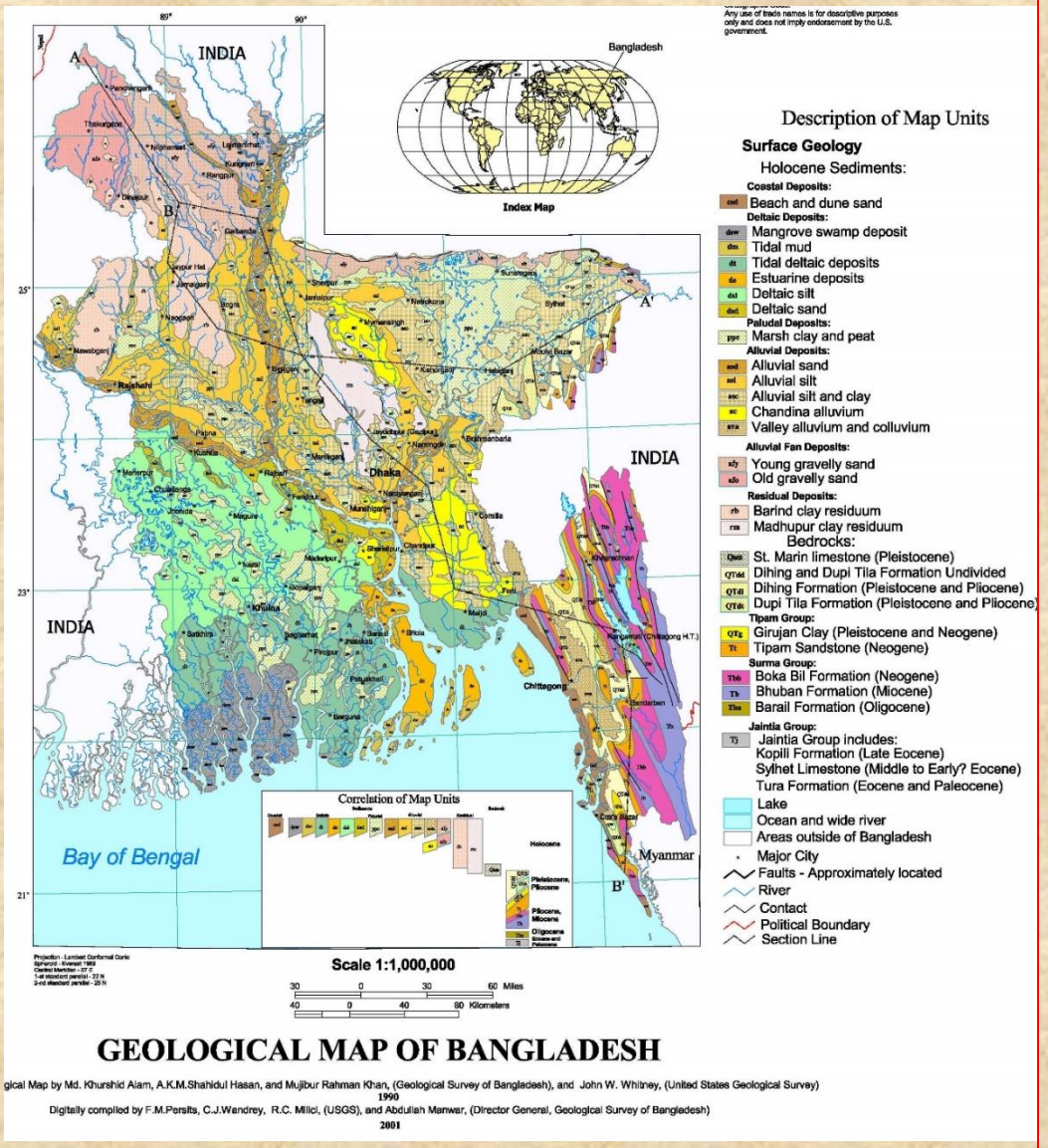
Table 3 : Stratigraphic Table for the Chalanbil area.

Chronostratigraphy		Formation	Member	Bed	Lithologic description	Thickness (m)
Series	Sub-Series					
HOLOCENE	Sub-Atlantic	Chalanbil Silty-clay		Sand-silt-clay	Olive (5Y 5/3) to grey (5Y 5/1) silty clay to sand-silt-clay. Very sticky clay, containing Fe-concretions and plant roots.	1-5
					Unconformity	
	Sub-Boreal			Silty clay	Light yellowish brown (2.5Y 6/4) silty-clay, containing plant roots and Fe-concretions. The lower part is mottled.	3
					Unconformity	
Pleistocene	Lower	Barind	Gujorghat Sand		Pale yellowish brown (10R 6/2) silty-sand to sand. It is highly micaceous and cross bedded, contains Mn-spots. Micas are biotitic and highly oxidized. It contains some intraformational clay layers.	3
					Unconformity	
PLIOCENE		Dupi Tila			Quartz-chalcedony Gravel Bed	
					Oxidized sands with intraformational clay beds. It contins large silicified woods	

Quaternary Stratigraphy : Dahagram-Panchagarh Area



GEOLOGICAL MAP OF BANGLADESH

gical Map by Md. Khurshid Alam, A.K.M.Shahidul Hasan, and Mujibur Rahman Khan, (Geological Survey of Bangladesh), and John W. Whitney, (United States Geological Survey)
1990

Digitally compiled by F.M.Persits, C.J.Wandrey, R.C. Milici, (USGS), and Abdullah Marwar, (Director General, Geological Survey of Bangladesh)
2001

- Dahagram-Panchagarh area is situated at the northern extremity of Bangladesh and represents an alluvial fan since many rivers issuing from the Terai regions at the foot of Himalayan ranges.
- These rivers very often change their courses.
- The entire region has a very gently undulating topography lying above the present day flood level.
- The palaeoriver system left a number of terraces at northern margin of Tetulia.

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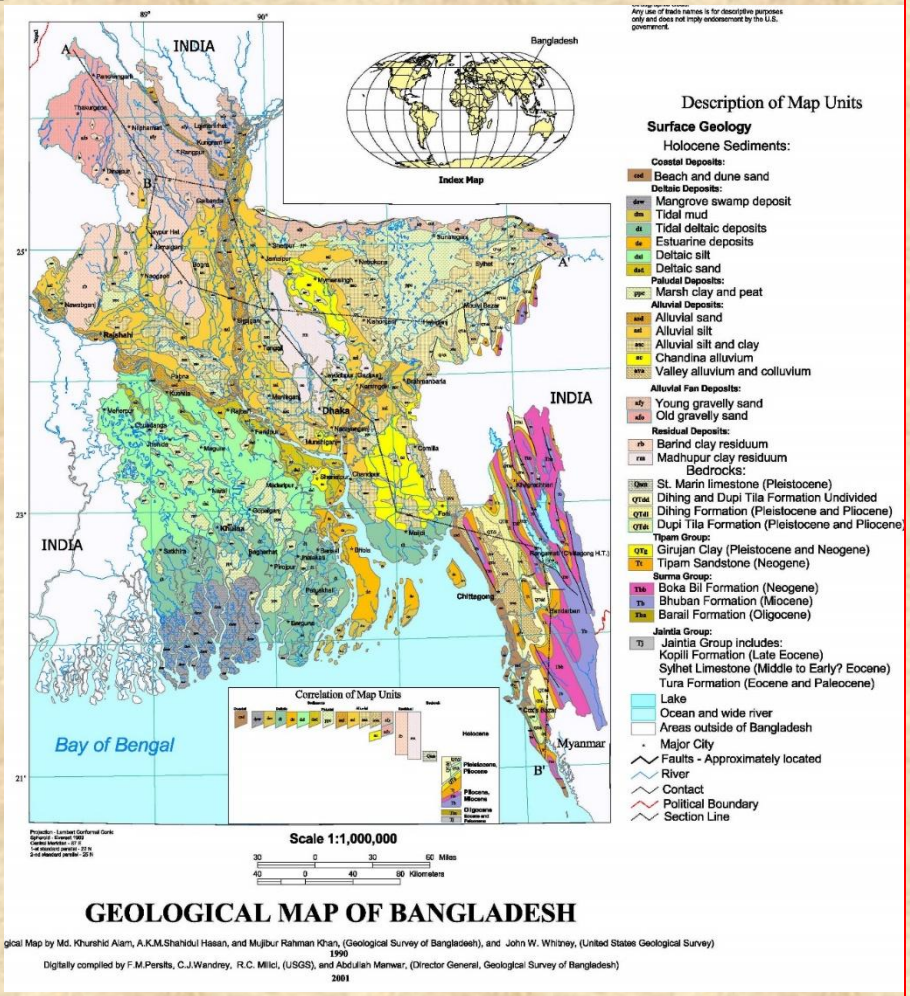
- The whole area (Tetulia, Panchagarh, Dalia, Patgram, Dahagram and Angarpota) is covered with a series of gravel beds alternated with coarse to medium sand layers.
- These gravel beds were considered as piedmont deposits (Khan, 1991). These gravels are quite fresh with high sphericity and roundness values.
- These gravels are composed of granite, quartz and quartzite, gneiss and schistose.
- The thickness of these gravel beds sometimes exceeds 20 meters. These gravels beds are called **Panchagarh Gravel Beds** (Morshed, 1994).
- The Panchagarh Gravels are overlain by a series of sand or silty-sand are called **Boalmari Sand Formation.**
- Panchagarh Gravel Beds belong to the upper Pleistocene Series whereas the Boalmari Sand Formation belongs to the Holocene Series.

Quaternary Stratigraphy : Jaintiapur-Bholagonj Area



- The area lie in the north eastern part of Sylhet district.
- The Jaintiapur and its adjoining areas are hilly region which are the extension of the Assam-Meghalaya Hill Range.
- North of the area lie the great Jaintia and Khasi Hills of India.
- The hills are gently undulated. The regional topography of the area is characterized by low rounded hillocks with numerous gullies, spurs, cliffs and scarps.
- The Bholagonj and its adjoining areas are a piedmont alluvial plain of the Khasi-Jaintia Hills.

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- In the hilly region of the Bengal basin Quaternary deposits are exposed in the valley areas. It is quite interesting to note that thick gravel deposits cap the hill tops of the Jaintiapur and Bholagonj areas.
- Gravel deposits are highly weathered and thought to be Pleistocene age (Evans, 1932).
- The gravel deposits unconformably overlie the Dupi Tila Formation are called Dihing Formation.
- It is more likely that the gravel deposits which cap the Jaintiapur hill tops belong to the Dihing Formation.
- These gravels are composed of granite, quartz and quartzite, sandstone and shally materials. The gravels of the high terraces unconformably overlie the Surma Group of sediment (erosional unconformity). They are highly weathered with high roundness and sphericity.

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- The gravel beds exposed at Jaintiapur, Mukambari, Sona Tila, Pather Tila and Muslimnagar hill tops represent the older terraces or high terraces.

- On the other hand, the gravel beds of the present river system at Dauki and Sripur make some terraces of Holocene epoch.These may be called as younger terraces or low terrace.

- Simultaneously, the gravel beds at Binda Tila hill tops represent the older terrace or high terrace and the gravels of the present river system of Bholagonj area represent low terrace or younger terrace of Holocene epoch.

- The gravels of high and low terraces have been considered as a single lithostratigruphic unit and are called **Sona Tila Gravel Beds and Bholagonj Gravel Beds** (Saha, 1994).

Quaternary: Economics Importance

- Bholagonj-Jaintiapur gravels are being used for roads and building constructions. Similarly, Gravels of Dahagram-Angarpota, Patgram, Dalia, Chapani, Kaligonj, north and south Kharibari, Boalmari, Vojonpur, Tetulia of greater Rangpur and Dinajpur districts, are also used as constructional materials.

- The Tista barriage is built up with our own local gravels. These gravels are exploited in a private level with local contractors.

- They are ruining the crop lands. It is suggested that the Government should take care of these gravels and take initiative for exploitation in a scientific way to minimize the exploitation costs and to save the crop lands for future generation.

Depositional History: Sona Tila and Bholagonj Gravel Beds

- Sona Tila and Bholagonj Gravel Beds belong to the Dihing Formation.
- In the early literature, it was mentioned that the Dihing Formation belongs to the Plio-Pleistocene age as they were affected folding and thrusting which had affected the Assam Teritories.
- Considering the weathering level, the gravels of the hill tops of Jaintiapur area (high terrace) seem to be lower Pleistocene age and are synchronous with the Madhupur Formation.
- It is quite likely that Sona Tila Gravels represent the upstream coarsest deposits of some palaeo river system and the Madhupur Clay Formation represents down stream finer sediments.
- It is to be mentioned that at present day, the Sona Tila Gravels and the Madhupur Formation in Lalmai hills are found at high elevation as capping rocks of Lalmai and Jaintiapur hills.

Depositional History: Sona Tila and Bholagonj Gravel Beds

- It means that the two areas were tectonically shocked and were elevated as block upliftment.
- Madhupr Clay belongs to the lower Pleistocene. Hence, the Lalmai hills were uplifted after the Lower Pleistocene Epoch.
- Similarly, the hillocks of the Jaintiapur area were also uplifted after lower Pleistocene time.
- It is quite well known that the final orogenic movement of the Himalayas was in the Middle Pleistocene.
- This movement, probably, changed the original morphology of the Jaintiapur and Lalmai hills.
- The new courses of the present river system left some Upper Pleistocene and Holocene terraces along their banks (low terrace).