Quaternary Geology

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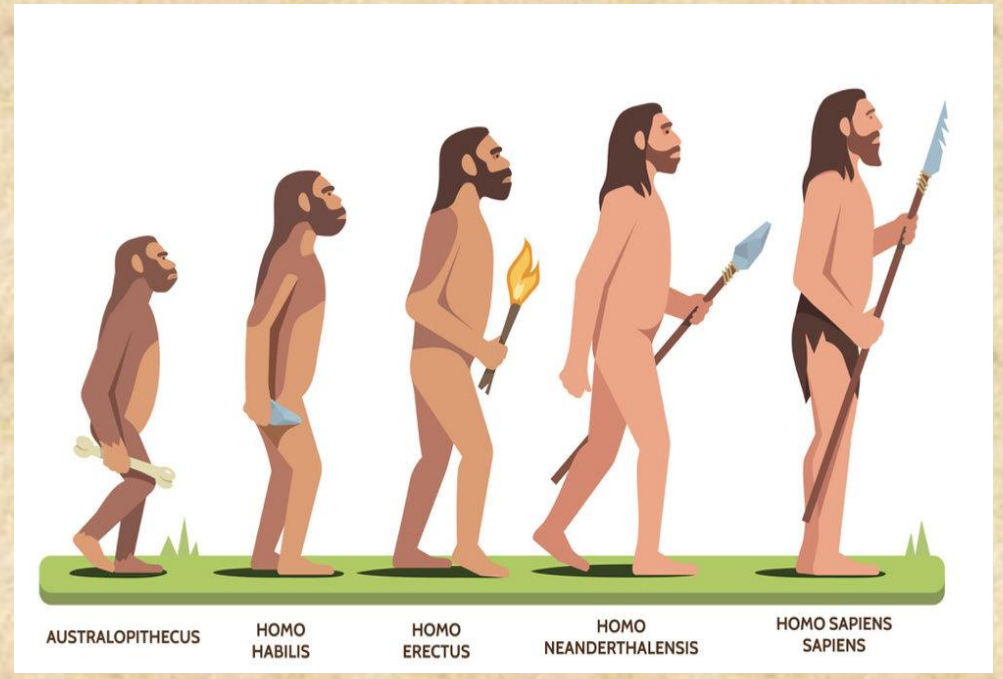

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Course outline

- **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**
  - Pedological Studies
  - Paleomagnetism and Rock Magnetism
  - Paleosoil and Micromorphology
  - Correlation of Quaternary Deposits

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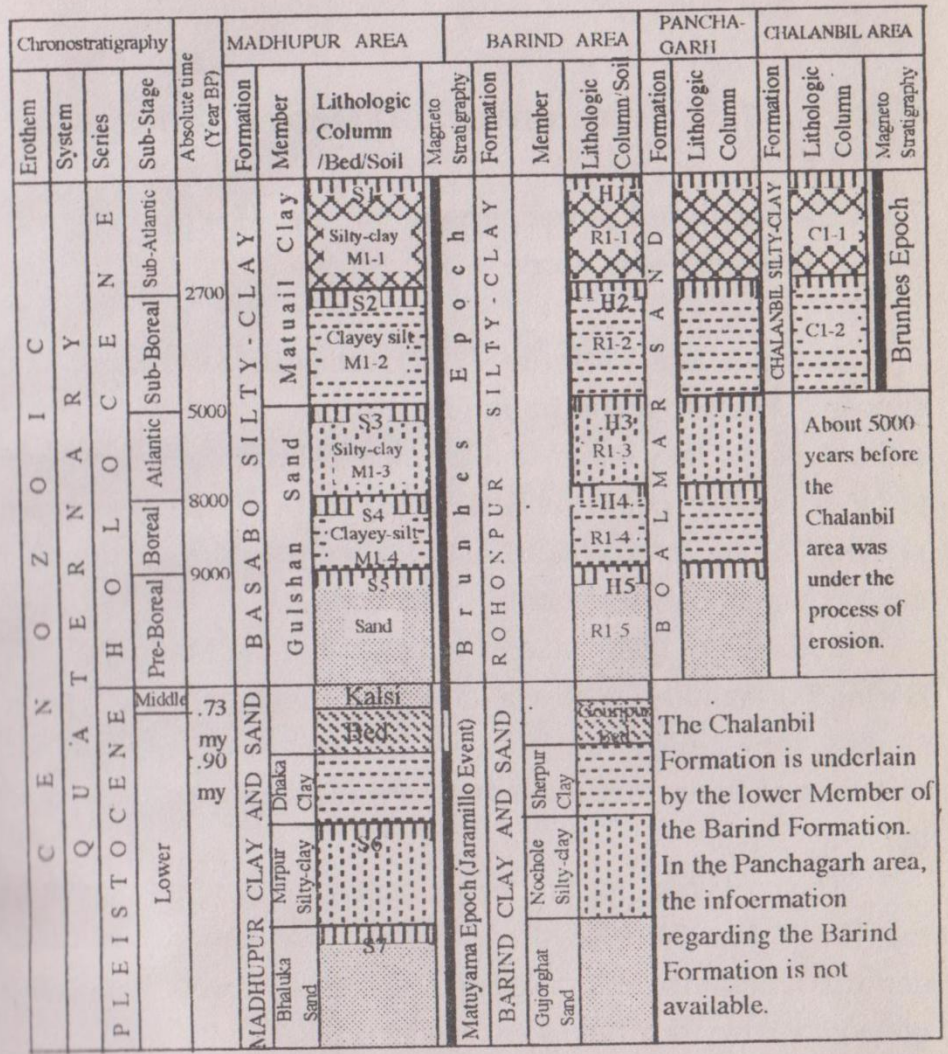
Correlation of Quaternary deposits of the different geomorphic units

Table 6 : Correlation scheme of the Quaternary deposits exposed at different areas.



Talk outline

- Depositional Environment of the Madhupur and Barind Formations
- Late Quaternary Monsoon climatic episodes
- Holocene Sea Level Change
- Neotectonics

Depositional Environment of the Madhupur and Barind Formations

- Morgan and McIntire (1959) considered the red bed deposits (Madhupur and Barind Formations) as the "Pleistocene terrace" which they assumed to be identical with the Mississippi terraces, but they could not find the existence of multiple terrace systems in the Bengal plain.

- But they were on the opinion that the Madhupur Clay represents fluvial deposits.

- Sedimentological studies indicate that the Madhupur and Barind Formations are fluvial deposits.

- Although these type of studies, now-a-days, are not so much important, even if, the matching of cumulative curves with the fluvial deposits has some meanings.

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- The cross bedding and ripple marks are quite prominent in the lower Members of these Formations.

- Moreover, these deposits contain wood fragments and plants roots which are quite indicative for a fluvial environment.

- A series of buried soils can be found in the fluvial flood plain.

- It was discussed that the Madhupur and Barind Formations contain two buried palaeosols.

- It is more likely that the Madhupur and Barind Formations represent cumulative palaeosols formed progressively with the increment of a few millimeter or a centimeter of sediment per year by numerous floods in the depositional basin (Monsur et al., 1992).

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- Therefore, the presence of buried palaeosol supports the statement of fluvial environment of deposition.

- Hence, it can be inferred that the depositional environment of the Madhupur and Barind Formation is fluvial.

- The lower Members of these Formations represents channel pattern and the middle and upper Members probably represent flood plain deposits.

Late Quaternary monsoon climatic episodes and the depositional history of the Bengal basin

- The peak of the last glaciation (18 kyr BP) was evidenced by dry climatic condition over the Bengal basin.
- The Himalayas were considerably high and were glaciated.
- Melt water was moving through a number of palaeoriver system over the Bengal basin.
- By that time the eustatic sea-level was about 100 to 130m below the present Mean Sea Level.
- Hence, the rivers were narrow and were deeply incised (Swatch of No Ground in the Bay of Bengal is a strong evidence).
- The monsoonic climate started changing between 18 to 15 kyr BP.

Late Quaternary monsoon climatic episodes and the depositional history of the Bengal basin

- At about 12 kyr BP, south-west monsoon became prominent which caused heavy rainfall.

- Therefore, at the end of the last glaciation (about 10,000 yrs BP) amplified monsoon water plus deglaciated melt water from the Himalayas enormously flowed through these narrow palaeoriver systems which were overloaded and overflowed.

- Due to the strong hydrodynamic condition, the initial Barind and Madhupur surfaces were highly dissected, created some local pools and depressions, left a number north-south elongated reddish-brown islands or terraces.

- The north-south elongation of the reddish brown terraces indicates the north-south directional water flow which supports this statement.

Late Quaternary monsoon climatic episodes and the depositional history of the Bengal basin

- The Chalanbil area represents such a dissected depression even today (Monsur, 1995).

- During this time, general morphology of the Madhupur and Barind tracts took their present shape (Fig.22).

- But the Lalmai hills and the Madhupur locality represent a tectonically uplifted blocks.

- Lalmai hill tops formed a kind of table surface.

- At the beginning of the Holocene, sea-level started rising very rapidly.

- About 5,500 yrs BP, sea-level attained its maximum height.

- The hydrodynamic condition of the river system was changed.

Late Quaternary monsoon climatic episodes and the depositional history of the Bengal basin

- Erosional activities ended and the erosional surfaces were filled up by the Holocene deposits.

- Due to the tremendous current, boulders and gravels from the Himalayas were carried away very far towards the south and were deposited over the vast plain extended from Tetulia to Dahagram (Panchagarh Gravel Beds).

- These upper Pleistocene gravels can be found in the Brahmaputra river valley as far as Sirajgonj.

- Heavy rainfall of the late Pleistocene Epoch generated a tremendous current in the hilly areas, like, Patheria hill ranges.

- The soft sands of Bokabil Formation were quickly eroded away leaving large concretions in the stream valleys.

Late Quaternary monsoon climatic episodes and the depositional history of the Bengal basin

- Huge concretions can be found in the stream sections of Patheria, in and around Borolekha in Sylhet district (Some sandstones of the Bokabil Formation contain large cpncretions of calcium carbonate).

- In the Barind and Madhupur tracts, middle and lower Members of the Barind and Madhupur Formations are overlain by Holocene deposits (Basabo and Chalanbil Formations).

- The Holocene infilling was not as high as the initial Madhupur surfaces.

- That's why, the Barind and Madhupur tracts apparently seem to be elevated compared to the surrounding flood plain.

- This apparent elevation of the flat surfaces of the Madhupur and Barind is an erosional feature and does not indicate a tectonic event.

Holocene sea-level and the marine transgressions of the eastern coast of the Bay of Bengal

- Several authors introduced Holocene sea-level curves.

- In this regard, there are two schools of thoughts: one group believes rapidly fluctuating sea-level hypothesis (Fairbridge, 1961; Curray, 1965) and the other group believes smoothly varying sea-level hypothesis (Jelgersma, 1961; Shepard, 1963).

- The contribution of climate to the sea-level fluctuations more rationally supports the rapidly fluctuating sea-level hypothesis.

- Minor climatic change results a small scale marine transgression.

- The existence of supratidal flat worldwide is the result of the high stand sea-level of 6000 - 5000 yrs BP.

- During the maximum high stand of sea-level (about 5500 yrs BP), oceanic waves acted on the foot of the hillocks from Cox's Bazar to Teknaf.

Holocene sea-level and the marine transgressions of the eastern coast of the Bay of Bengal

- About 18,000 yrs BP, shore line of the Bay of Bengal was some hundreds of killometers southward from the present coast.

- At the end of the last glaciation, eustatic sea-level started rapidly rising and the shoreline of the Bay of .Bengal started shifting northward (Fig.23, Monsur and Kamal, 1994).

- Holocene sea-level along the eastern bank of the Ganges estuary was accompanied by coastal erosion.

- A wide hilly area was existing westward from the present Cox's Bazar-Teknaf coast (i.e in the eastern bank of the Ganges estuary).

- These hillocks were made up of the Bokabil and Tipam Formation.

Holocene sea-level and the marine transgressions of the eastern coast of the Bay of Bengal

- These were the soft rock sediments and washed out quickly by the wave action.

- Only the concretions those can be found in the Bokabil Formation remained on the shoreline and in the continental shelf (yet to be explored).

- In the supratidal flat these concretions can be found under a thin venial of alluvium sediments.

- In a wide area towards the southern part of Teknaf town, these concretions are overlain by the recent sediments and can be found within the ancient beach sand.

- These concretions are extensively exposed at Inani beach and St. Martin's Island.

Holocene sea-level and the marine transgressions of the eastern coast of the Bay of Bengal

- High concentration of these concretions can be found at the palaeochannel sections where they were rolled out by the center of gravity along the 'V' shaped valleys and accumulated on the stream beds.

- Due to the invasion of the sea with erosion, the hillocks with their valleys and streams were eroded away leaving the concretions on the palaeobeach.

- Therefore, highconcentration of these concretions along the beach indicates a palaeochannel or palaeovalley of some undulated or hilly surfaces.

- These concretions are underlain by Bokabil Formation (shale).

Holocene sea-level and the marine transgressions of the eastern coast of the Bay of Bengal

- The existence of these concretions under the beach sand or recent deposits of the supratidal flat from Cox's Bazar to Teknaf indicates a palaebeach of the highstand (raised) Holocene sealevel.

- These concretions, probably, made a bed on the eastern shelf of the Bay of Bengal (from Cox's Bazar to Teknaf) due to the rise of sea-level and its erosional activities.

- Age of this bed covers the whole Holocene time. Existence of these concretions at the elevated beach indicates a sea-level rise.

- According to Fairbridge the maximum sea-level was about 5,500 yrs BP.

- Hence eastern extremity of the supratidal flat (i.e. at the foot of the hillocks) from Cox's Bazar to Teknaf indicates the coast line of 5,500 yrs BP.

Holocene sea-level and the marine transgressions of the eastern coast of the Bay of Bengal

- The sea started to retreat during the time span of the last 5,500 years, left a supratidal bench mark behind the present beach from Cox's Bazar to Teknaf.

- During the highstand of Holocene sea-level (5,500 yrs BP), some of the areas behind the Cox's Bazar cliff were submerged under marine water.

- Holocene tidal flat deposits with the interfingering peat layers can be found along the Cox'Bazar Chittagong road cut section behind Cox's Bazar town.

- It also indicates a sea-level rise. In the Maiskhali Island, the coast line or the beach of 5,500 yrs BP, was at the foot of the hillocks along the NalbilaGanakghata road (Fig.24).

- Maiskhali island is separated from the main land by the Maiskhali channel.

- The island is also separated from the Materbari island by the Materbari channel.

- The Maiskhali island is about 25 km long and 11 km wide.

- Morphologically the Maiskhali island can be subdivided into two equal halves : Eastern and Western halves, by a north-south elongated ancient (about 5,500 yrs BP) coast line which runs parrallel to the north Nalbila-Ganakghata road.

- The eastern half is still retaining the initial undulated hilly morphology with some minor hillocks of Neogene sediments (Bokabil and Tipam Formations).

- It is quite interesting to know that supratidal flat in the Maiskhali island has two steps: Step-1, and step-2 (Fig.24).

Holocene sea-level and the marine transgressions of the eastern coast of the Bay of Bengal

- Probably, these are the bench mark of two sea-level rise.
- Western half was eroded away due to the Holocene sea-level rise (or due to several sea-level rises of Pleistocene Epoch).
- In the western half (step-2), salt marsh, Tidal flat, Tidal channels and coastal lagoons are quite prominent.
- Wave action washed out the initial surface of the St. Martin's and Sonadia Islands.
- It means that at about 5,500 yrs BP the surfaces of these Islands were under marine water.
- The development of coquina bed and coral reefs on St. Martin's Island support this statement.

Holocene sea-level and the marine transgressions of the eastern coast of the Bay of Bengal

- In the foregoing discussion, it was clear that marine transgression on the eastern coast of the Bay of Bengal was accompanied by the erosion of soft rock sediments.

- Therefore, the invasion of the sea was quite faster. This is the reason why the continental shelf of the Bay of Bengal on the eastern coast slopes gently (2° - 8°).

- During this high stand of Holocene sea-level, islands of southern coast of the Bay of Bengal, such as, Sandip, Nijhumdip, Hatia, Kutubdia, Materbari etc. were just rising and their present surfaces were below the ambient high tide level.

- After 5,500 year BP, the Holocene sea-level started dropping and the surfaces of these Island came into the aerial exposition.

Some aspects of neo-tectonics

- Most of the authors have the opinion that the Madhupur and Barind tracts represent a tectonic uplifted surfaces.

- Fergusson (1963) believed that the Madhupur region was uplifted in very recent time and refereed to the earth-quake of 1762.

- He suggested that the Madhupur jungle occurs along the axis of the belt of Volcano action which extends in a northwestern direction through Chittagong and Dhaka.

- Fergusson considered a numerous low lakes in the Sylhet basin to be caused by subsidence compensatory to the elevation of the Madhupur jungle.

- Morgan and McIntire (1959) noted a series of en-echelon faults (six in number) flaking the western side of the uplifted Madhupur jungle.

Some aspects of neo-tectonics

- According to them, uplift of the Barind and Tippera coupled with subsidence of the Sylhet basin and Deltaic plain resulted in torsion of the crust in the Bengal plain.

- They believed that surface en-echelon faulting of the Madhupur jungle resulted either from torsion of the region or from the effect of shear along a postulated buried fault or possibly a combination of both.

- The courses of the Bengal rivers changed during a considerable distance, even, during the historical time.

- For example, the diversion of the Brahmaputra river is important.

- By the early 1770 s the major diversion of the Brahmaputra occurred into its present channel, west of the Madhupur jungle.

- There is no complete agreement as to when this diversion down the Jenai (probably the present name "Jamuna" has been derived from the name "Jenai") river of Runnel (1781) occurred.

- A generally accepted more rational explanation of LaTouche (1910) can be cited.

- He felt that the old Brahmaputra course flowed through the east of Madhupur jungle which was a relic of the old delta face of the Ganges.

- He considered the entire Bengal basin (excluding the Sylhet basin) as the sole regime of the Ganges prior to the sudden increase in Brahmaputra water volume.

- He suggested that the diversion of the additional water volume of the Tista river from the Ganges to the Brahmaputra in 1787 was the final action that trigegered the diversion of the Brahmaputra river down the old Jenai channel west of the Madhupur jungle.

- Therefore, for about 200 years Brahmaputra river was laterally shifted about 100 km westward.

Some aspects of neo-tectonics

- Bagchi, (1944) described a beautiful explanation from the mythological stories of Ramayana, Mahabharata and from the writings of Ptolemy (150 A.D.) and Megasthenes and Periplus (300 B.C.).

- Kanangopal Bagchi (1944) was sure that the birth of the Padma (the principal course of the Ganges) took place before 300 B.C.

- Before the birth of the Padma, the Bhagirathi was the principal course of the Ganges.

- It means that in early times, the Ganges was discharging its water into the Bay of Bengal about 200 km more westward (through the Bhagirathi river) from the present point of discharge of the river Mehgna.

- Some geologists give more emphasis on the fact that the courses of Bengal rivers changed due to the uplift of the Madhupur and Barind tracts.

Some aspects of neo-tectonics

- They believe that due to the neotectonics, Madhupur area is uplifting very slowly, and as a result , the old Brahmaputra river changed its course and shaped into the present position (Jamuna).

- Other group of geologists believe that due to the neotectonic effect (still active), the courses of the Ganges river system laterally has been shifting from the west towards the east.

- The gradual uplift of western part of the basin resulted in the shifting of the Ganges river towards the east However, the opinion of the present author differs.

- The author believes that the Barind and Madhupur tracts represent not a tectonic block, but an erosional feature.

Some aspects of neo-tectonics

- In fact, the Lalmai hills and the locality of Madhupur, resulted due to the block uplift during the middle Pleistocene time.

- But the rest of the areas of Madhupur and Barind tracts represent an erosional feature.

- In stratigraphic sections of the central part of the Madhupur and Barind, all the three Members can be seen.

- But in the marginal areas, the middle or lower Member is overlain by the Holocene deposits.

- This is because of the fact that the upper or middle Member of these Formations were eroded away and on the erosional surface the Holocene Series had been deposited.

- Very close to the main reddish-brown terraces, some small terraces can be found.

- Sometimes these may have underground lithologic continuity with the main island (or terrace) by the middle or lower Members of these Formations or sometime they do not have any lithologic continuity.

- It means that all the deposits of the Madhupur and Barind Formations were eroded away and the dissected surfaces were filled up with the recent sediments.

- That's why, there is a lack of lithologic continuity. In the foregoing discussion, the author has mentioned that during the Late Pleistocene time, amplified monsoonic rainfall and deglaciated melt water enormously flowed over the Bengal plain.

- As a result, the Madhupur and Barind surfaces were eroded away leaving these reddish brown islands, created some pools and depressions.

- The Holocene sea-level rise changed the hydrodynamic condition of the palaeoriver system. As a result, these dissected surfaces were filled up with the alluvial sediments. But the initial Madhupur and Barind surfaces remained as an elevated islands.

Some aspects of neo-tectonics

- It is quite interesting to know when the Chittagong hill ranges came into being. Cox's Bazar - Teknaf beach more or - less parallel to the axial line of an anticline.

- High dip of some beds along the beach indicates local faulting of Neogene sediments.

- From the discussion regarding Holocene marine transgressions, it was clear that undulated or hilly surfaces were existing in and around Cox's Bazar-Teknaf during pre-Holocene time.

- So, it can be assumed that the Cox's Bazar folded belt originated not after 10,000 to 15,000 yrs BP i. e. they were originated before upper Pleistocene-Holocene time (Monsur and Kamal, 1994).

- Chittagong and Jaintiapur hill ranges fall in the Arakan Yoma folded belt.

- All these hill ranges responded simultaneously during the tectonic activities.

Some aspects of neo-tectonics

- In Jaintiapur area, lower Pleistocene boulder-gravels (Sonatila Gravel Beds, Shaha, 1994) are well exposed on hill tops of Sonatila, Mokambari and Jaintiapur locality.
- Sphericity and roundness of these gravels indicate that they were river borne deposits.
- Therefore, those hills were elevated after the deposition of those gravels.
- From this evidence, it can be assumed that Jaintiapur hills close to the margin of plainland were uplifted after lower Pleistocene time.
- Since the Jointiapur and Chittagong hill ranges belong to the same tectonic belt, then probably, the Jaintiapur hills and the Cox's Bazar cliffs were uplifted synchronously.
- From the above discussion, it is clear that they were uplifted after Lower Pleistocene and not after Upper Pleistocene or Holocene epoch.
- Hence, their time of upliftment would be the Middle Pleistocene. This time of upliftment of these hill ranges coincides with the major or final orogenic movement of the Himalayas during Middle Pleistocene time.