Facies Characteristics, Depositional Environments and Sequences Stratigraphy of the Yaw Formation and Shwezetaw Formation Exposed in Padan Area, Ngape and Minbu Townships, Magway Region

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Abstract

The study area lies in southwestern part of Minbu Basin, 26 miles SW of Minbu. Yaw Formation (Late Eocene) is mainly composed of bluish grey clays, sandstone, sub bituminous coal seams and sand-shale interbeds. Shwezetaw Formation (Early Oligocene) consists of fine- to medium-grained, glauconitic and fossiliferous sandstones, sandy shale and silty sands. According to, the distinctive lithologic features including colour, bedding, composition, texture, fossils and sedimentary structures, eighteen (18) lithofacies are recognized and four (4) lithofacies associations were distinguished. Based on the field observations, lithofacies analysis and sequence stratigraphic concepts, Eocene and Oligocene boundary is represented by seven cyclothems in Yaw Formation and two cyclothems in Shwezetaw Formation. Three distinct types of cyclothems and type 1 sequence boundary (marine bands) are recognized, based on their bounding surfaces and internal facies architecture. Type1 cyclothems are dominated by deltaic shorelines deposited during a falling stage and lowstand of sea level. Type 2 cyclothems represent the lower delta plain, the falling stage and lowstand deltas. Type 3 cyclothems comprise mainly upper delta plain deposits. The marine bands, widespread coals and coal seam groups that bound these three cyclothems types record abandonment of the delta system during periods of rapid sea-level rise. It is reasonable concluded that most of the sediments in the Padan area were probably deposited under delta front, fluvial and delta plain environments during Late Eocene to Early Oligocene time.

Keywords: facies architecture, cyclothems, sequence boundary

Introduction

The study area lies in southwestern part of Minbu Basin, 26 miles SW of Minbu. Padan area is located in one inch topographic maps of 85 I/9 and 84 L/12. It is bounded by Latitudes 19˚59΄ to 20˚ 02΄ North and Longitudes 94˚34΄ to 94˚ 37΄ East. The rocks of the Padan area can be differentiated into four lithostratigraphic units of the formation rank on the basis of sand-shale ratio, stratigraphic relationship and faunal content. From older to younger rock units are; (1) Pondaung Formation, (2) Yaw Formation, (3) Shwezetaw Formation and (4) Padaung Formation. Present study is only two formations of Yaw Formation (Eocene) and Shwezetaw Formation (Oligocene). Location map of the Padan area is shown in Fig.1.

Yaw Formation is mainly composed of bluish grey clays, sandstone, sub bituminous coal seams and sand-shale interbed sequence. In the lower part of Yaw Formation, medium-grained, thin- to medium-bedded sandstone with small scale planar type cross stratification are present. Coaly mudstone, variegated clay and siltstone are also present. The upper part of is mainly composed of bluish grey, crudely bedded siltstone, concretionary mudstone and sand-shale interbed sequence. Lenticular bedded sandstone, bioturbated sandstone, fossiliferous sandstone and clay pebbles are occurred. Coaly mudstone and wood fossils are
also noted in the uppermost of the Yaw Formation. Shwezetaw Formation consists of fine- to medium-grained, glauconitic and fossiliferous sandstones, sandy shale and silty sands. Medium-grained, thin- to medium-bedded wavy and lenticular bedded sandstone and sand-shale interbed sequence are also occurred. Shale and mudstone are rare and sandy shale are intercalated between the thick-bedded sandstone. Clay pebbles and iron concretions (1 - 4 cm in diameter) are present in light grey, medium-grained, medium-bedded sandstone of the upper part of the Shwezetaw Formation.

Methodology

In order to study the sedimentology and sequence stratigraphy of the Padan area, the research will lead to (1) recording and checking of lithologic character, nature of their contact, sedimentary structures and tectonic deformation; (2) preparing of columnar stratigraphic sections and correlation of local sections; (3) identification and age determination of the lithologic units with the aid of collected fossils, and (4) considering the lithofacies present, depositional processes, and environmental interpretation.
Reconstructing of facies model for coal-bearing sequences and sequence stratigraphic interpretation are based on particular set of sediments characteristics, lithology, texture, suite of sedimentary structures, fossil content, colour, geometry and paleocurrent pattern. In the present study, three detail sections are measured along the Minbu-Padan car road, coal mine and stream sections. All sections crop out along car road cuts or in mountain cliffs. The sections have been measured bed by bed, and samples have been taken every few centimeters or tens of centimeters, depending on facies changes.

Lithofacies Analysis And Lithofacies Association

General Statement

Mollassic type of sediments belonging to the Eocene Yaw Formation and Oligocene Shwezetaw Formation occupy the Padan area. Although four stratigraphic units are exposed in the Padan area, the author studied and expressed Shwezetaw Formation and unconformably underlying unit of Yaw Formation. Lithofacies is a body of rock and it is defined on the basis of its distinctive lithologic features including colour, bedding, composition, texture, fossils and sedimentary structures (Reading, 1980). Each lithofacies represents an individual depositional event. Therefore, lithofacies may be grouped into lithofacies associations or assemblages, which are characteristics of particular depositional environment (Miall, 1984).

Lithofacies Analysis

In the research area, at least (18) lithofacies are recognized for Yaw and Shwezetaw formations. Their brief descriptions with interpretations are given in Table (1.a-b). Detailed columnar sections are shown in figure (5,6,7,8).

Lithofacies Associations

Two or more facies, which were formed in a single depositional environment at the same time, are grouped into a facies association. A facies association can thus be used for more detailed interpretation of depositional environments. The (18) lithofacies have been classified on the basis of sedimentary structures, lithology and fossils. The (4) lithofacies associations were distinguished with respect to their lithology, facies successions and bed geometry. They are marine bands (or) shoreface facies association, delta front facies association, fluvial facies association, delta plain facies association and fluvial facies association.

Marine Bands (or) Shoreface Facies Association

Marine bands and laterally equivalent shales comprise dark grey, non- to poorly bioturbated, flat laminated, fissile mudstones, commonly with abundant body fossils. These mudstones occur in thin (<1 m), regionally extensive bands. Body fossils may constitute either a marine pelagic fauna commonly containing pectinid bivalves or a brackish water fauna (Fig.4. C).

Interpretation

The marine bands represent condensed deposition from suspension in quite-water environment starved of coarse clastic sediment. Mudstones with a marine fauna were deposited under fully marine salinities with an anoxic substrate and bottom waters, which precluded bioturbation and the development of a benthic fauna, and oxygenated upper waters, which sustained a pelagic fauna.
Table. (1.a) Facies scheme for Yaw Formation and Shwezetaw Formation, Padan area, Minbu and Ngape Townships, Magway Region.

<table>
<thead>
<tr>
<th>Facies</th>
<th>Grain size</th>
<th>Bed Thickness (cm)</th>
<th>Sedimentary Structures</th>
<th>Boundaries</th>
<th>Interpretation</th>
<th>Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Clay pebbles Conglomerate</td>
<td>Pebble</td>
<td>7 - 46</td>
<td>Lack of internal structure</td>
<td>Sharp, lag deposit at the base of the tidal channel</td>
<td>Yaw, Shwezetaw</td>
</tr>
<tr>
<td>B</td>
<td>Fossiliferous Sandstone</td>
<td>Fine-medium sand</td>
<td>27</td>
<td>Lack of internal structure</td>
<td>Sharp, straight, lower shore face deposit</td>
<td>Shwezetaw</td>
</tr>
<tr>
<td>C</td>
<td>Sandstone with Concretion</td>
<td>Medium Sand</td>
<td>100</td>
<td>Sandstone concretions (diameter 2-160cm)</td>
<td>Sharp</td>
<td>Beach ridge develops on marshy regions</td>
</tr>
<tr>
<td>D</td>
<td>Trough type cross-laminated Sandstone</td>
<td>Fine-medium sand</td>
<td>36 - 65</td>
<td>Small scale trough cross stratification</td>
<td>erosive</td>
<td>Tidal fat, fluvial, Tidal channel</td>
</tr>
<tr>
<td>E</td>
<td>Planar-cross bedded Sandstone</td>
<td>Medium Sand</td>
<td>30</td>
<td>Planar-type cross bedding</td>
<td>Sharp, erosional, Upper shoreface, channel bar</td>
<td>Yaw, Shwezetaw</td>
</tr>
<tr>
<td>F</td>
<td>Horizontal laminated Sandstone</td>
<td>Medium Sand</td>
<td>12 - 17</td>
<td>Lack of internal structure</td>
<td>Sharp</td>
<td>Tidal channel</td>
</tr>
<tr>
<td>G</td>
<td>Flaser bedded Sandstone</td>
<td>Medium Sand</td>
<td>7 - 240</td>
<td>Flaser bedding</td>
<td>Sharp</td>
<td>Tidal sand flats</td>
</tr>
<tr>
<td>H</td>
<td>Lenticular bedded Sandstone</td>
<td>Fine-medium sand</td>
<td>1000</td>
<td>Lenticular bedding</td>
<td>Sharp, gradational, tidal mixed flats, tidal channel and delta</td>
<td>Shwezetaw</td>
</tr>
<tr>
<td>I</td>
<td>Hummocky cross-stratified Sandstone</td>
<td>Fine-medium sand</td>
<td>50</td>
<td>hummocky cross-stratification</td>
<td>Sharp, gradational, Storm conditions on a shelf, upper shoreface</td>
<td>Yaw</td>
</tr>
</tbody>
</table>
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Table. (1.b) Facies scheme for Yaw Formation and Shwezetaw Formation, Padan area, Minbu and Ngape Townships, Magway Region

<table>
<thead>
<tr>
<th>Facies Code</th>
<th>Facies Description</th>
<th>Thickness</th>
<th>Textural and Structural Features</th>
<th>Sedimentary Facies</th>
<th>Environment/Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>Tidal bundles Sandstone</td>
<td>Fine-medium sand</td>
<td>70</td>
<td>tidal bundles</td>
<td>Sharp, gradational</td>
</tr>
<tr>
<td>K</td>
<td>Sandstone with herringbone cross-stratification</td>
<td>Fine sand</td>
<td>70</td>
<td>Herringbone cross-beding</td>
<td>Sharp, gradational</td>
</tr>
<tr>
<td>L</td>
<td>Bioturbated Sandstone</td>
<td>Fine sand</td>
<td></td>
<td>Complex networks of burrows</td>
<td>Sharp, gradational</td>
</tr>
<tr>
<td>M</td>
<td>Sandstone with load cast</td>
<td>Medium sand</td>
<td>30</td>
<td>Flute cast, Load Cast</td>
<td>Sharp, Gradational</td>
</tr>
<tr>
<td>N</td>
<td>Convolute laminated Sandstone</td>
<td>Fine Sand</td>
<td>30</td>
<td>Water escape structure/Convolute laminated</td>
<td>Sharp, Gradational</td>
</tr>
<tr>
<td>O</td>
<td>Variegated clay interbedded with Sandstone</td>
<td>Fine-medium sand</td>
<td>450</td>
<td>Caliche, coal seams</td>
<td>Gradational</td>
</tr>
<tr>
<td>P</td>
<td>Laminated shale intercalated with fine sand and coal layer</td>
<td>Fine sand</td>
<td>200</td>
<td>Organic debris</td>
<td>Gradational</td>
</tr>
<tr>
<td>Q</td>
<td>Crudely bedded siltstone and mudstone</td>
<td>Silt, mud</td>
<td>300</td>
<td>Concretions</td>
<td>Sharp, Gradational</td>
</tr>
<tr>
<td>R</td>
<td>Massive coaly mudstone</td>
<td>Clay</td>
<td>500</td>
<td>Coal chips</td>
<td>Gradational</td>
</tr>
</tbody>
</table>
Shales containing brackish water fauna were deposited under restricted marine salinities with a poorly oxic substrate, allowing rare bioturbation, and oxygenated bottom and upper waters, which sustained both benthic and pelagic faunas. The lateral transition from marine to brackish water fauna within each marine band reflects a palaeogeographical transition from deeper, poorly circulated, marine environments to shallower, marginal-marine, brackish environments diluted by freshwater fluvial input (Rabitz, 1966).

**Delta Front Facies Association (DFFA)**

Delta front successions can be subdivided into three distinct sub associations (DFFA-1, DFFA-2 and DFFA-3) at outcrop data.

The first sub association (DFFA-1), which forms the basal part of a succession, consists of dark grey slightly bioturbated, flat laminated shales and siltstones (Fig.2.B). These facies grade upwards into the second sub association (DFFA-2), which consists of interlaminated and thinly interbedded siltstones and fine-grained sandstones. Sub association (DFFA-3) comprises fine- to medium-grained micaceous sandstone with rare siltstone partings.

**Delta Plain Facies Associations (DPFA)**

In other Coal Measures facies schemes (e.g.Fielding,1984), several delta plain facies containing a similar assemblage of sedimentary structures are distinguished by facies body geometries and internal trends in grain size trends and the presence or absence of key structures, such as root and freshwater fauna.

Two delta plain facies associations are identified. Coarsening-upward trend (DPFA-1) and a relatively uniform grain size trend (DPFA-2).

The basal part of the former, coarsening-upward successions (DPFA-1) is dominated by siltstone and sandstone. Overlying strata contain sandstone beds that coarsen, thicken and amalgamate, there by producing an overall coarsening upward trend in grain size (Fig.5). The latter successions (DPFA-2) lack consistent upward trends in grain size, bed thickness and bed amalgamation. Siltstone and sandstone beds contain a similar suite of sedimentary structures and trace fossils as in DPFA-1.

**Fluvial Facies Association (FFA)**

Two fluvial facies associations are recognized in the middle part of the Yaw Formation (Fig.7). They are single-storey sandstone bodies of fluvial facies association (FFA-1) and multistorey, blocky and complex sandstones of fluvial facies association (FFA-2). The first (FFA-1) comprises narrow sandstone bodies, which can only rarely be traced and infer to be channelized. The second fluvial facies association (FFA-2) has a multistorey character and comprises cross-bedded, medium- to coarse-grained sandstone in bodies of 15-50 m thick.

**Sequence Stratigraphy**

The term “sequence” was introduced by Sloss et al., 1949 to designate a stratigraphic unit bounded by subaerial unconformities. Sloss also emphasized the importance of such sequence bounding unconformities and tectonism in the generation of sequences and bounding unconformities in 1963. The study of rock relationships within a time-stratigraphic framework of repetitive, genetically related strata is bounded by surfaces erosion or nondeposition, or their correlative conformities (Posamentier et al., 1988; Van Wagoner, 1995). In the simplest sense, sequence stratigraphy deals with the
Sedimentary response to base-level changes, which can be analyzed from the scale of individual depositional systems to the scale of entire basins. There are many definitions for sequence stratigraphy and the key sequence stratigraphic concepts.

Sequence stratigraphy is the most recent and revolutionary paradigm in the field of sedimentary geology. Sequence stratigraphy is the study of genetically related facies within a framework of chronostratigraphically significant surfaces (Van Wagoner et al., 1990). Thus, the sequence stratigraphic approach has led to improve understanding of how stratigraphic units, facies tracts, and depositional elements relate to each other in time and space within sedimentary basin. Sequence stratigraphy is commonly regarded as only one other type of stratigraphy, which focuses on changes in depositional trends and their correlation across a basin. Sequence stratigraphy is generally used to resolve and explain issues of facies cyclicity, facies association and relationship and reservoir compartmentalization, without necessarily applying this information for large-scale correlation (Octavian Catuneanu, 2006). Cyclicity: a sequence is a cyclothem, that is corresponds to a stratigraphic cycle or a vertical stratigraphic sequence caused by repeated flooding by the sea.

**Type of Cyclothem**

In the study area, there are seven cyclothsms in Yaw Formation and the two cyclothsms in Shwezetaw Formation. Three distinct types of cyclothsms and Type 1 Sequence Boundary are recognized, based on their bounding surfaces and internal facies architecture.

1. **Type 1 cyclothsms** are bounded by marine bands. Each cyclothem comprises a thick (30-80 m), regionally extensive, coarsening-upward delta front succession of interbedded shales, siltstones and sandstones, which may be deeply incised by a major fluvial sandstone complex. The delta front succession is capped by a thin (<1m), regionally extensive coal seam and an overlying marine band defining the top of the cyclothem (Hampson et al., 1999). 2. **Type 2 cyclothsms** are bounded by thick (≈1m), regionally extensive coal seams with few splits. The basal part of a typical cyclothem comprises a thick (15-50m), widespread, coarsening-upward delta front or lake infill succession consisting of interbedded shales, siltstones and sandstones. Multistory fluvial sandstone complexes erode deeply into and, in some cases, through these successions and are overlain by the coal seam defining the cyclothem top (Hampson et al., 1999).
3. **Type 3 cyclothsms** are bounded by regionally extensive coalseam groups, characterized by numerous seam splits on a local (0.-10 km) scale. Intervening strata vary in thickness (15-60 m) and are characterized by strong local facies variability (Hampson et al., 1999).

In the Yaw Formation, cyclothsms E-1, E-2 and E-6 are type 1 cyclothsms. Cyclothsms E-3 and E-7 are type 2 cyclothsms. Cyclothsms E-5 is type 3 cyclothem. Cyclothsms E-4 is a fluvial sequence (Fig. 5, 6, 7).

A sequence composed of lowstand, transgressive and highstand systems tracts was defined as a “type 1” sequence, whereas a combination of shelf-margin, transgressive and highstand systems tracts was said to have formed a “type 2” sequence (Posamentier and Vail, 1988). In the Shwezetaw Formation of the Padan area, sequence boundary O-1 and O-2 are type 1 sequence boundary (Fig.4.A) (Fig.8).
Sequence Stratigraphic Implication

Detailed Study of Sequence

In the present area, the study of sequence is mainly based on the sedimentary facies analysis. The cyclothems or parasequence recognition, their stacking characteristic, and system tracts demarcations (lowstand system tract – LST, transgressive system tract– TST, highstand system tract– HST, maximum flooding surface– MFS) according the Van Wagoner, 1991. According to the development of the sequences, acquired results are applied to study the tectonic fabric, basin evolution, the sedimentation and the condition of episodic sea level fluctuation. The stacking pattern of sedimentary sequences in the study area is described in figures (Fig.9. A-B).

Lowstand System Tracts (LST)

Figure (2) The lower part of Yaw and Shwezetaw formations are mainly made up of clay, shale, siltstone and sand bodies of the lowstand system tracts (LST), (A) Coal seams represent local and/or regional delta plain abandonment during a prolonged period of rising base level (LST); (B) Prodelta deposits (DFFA 1) of coal seams and coaly mudstone may be deposited during the falling stage of lowstand system tracts (LST); (C) Multi-colored silty clay (variegated clays) interbedded with buff colored sandstone and coal seams are characteristic of crevasses splay deposit and (D) Siltstone and clay pebbles are delta front deposition during early part of sea-level fall (lowstand system tracts -LST).
The interval of low sea level is called a lowstand and the deposits of this period are called the lowstand system tracts (LST) (Gary Nichols, 2009). A system tract includes all strata accumulated across the basin during a particular stage of shoreline shift. System tracts are interpreted based on strata stacking patterns, position within the sequence and types of bounding surfaces. The lowstand system tracts (LST) is bounded by the subaerial unconformity and its marine correlative conformity at the base, and by the maximum regressive surface at the top. Lowstand deposits typically consist of the coarsest sediment fraction of both nonmarine and shallow marine deposits (Octavian Catuneanu, 2006). The lower part of the Yaw Formation and Shwezetaw Formation are mainly made up of delta plain and delta front (mouth bar) deposits of shale, siltstone, gravelly and sandbodies of the LST deposits (Fig. 2. A-D). During late highstand to lowstand, as sea-level starts to fall and it may increase the gradient of the river. This might result in more erosion upstream, increasing the sediment load. Braided rivers would have a greater capacity for carrying the increased sediment load (Schumm and Khan, 1972).

In contrast to the falling-stage systems tract, the sediment of this stage of early-rise normal regression is more evenly distributed between the fluvial, coastal and deep-water systems. Sand is present in amalgamated fluvial channel fills, beach and delta front systems, as well as in submarine fans. The lowstand prism gradually expands landward via fluvial aggradation and onlap. The top of all early-rise normal regressive deposits is marked by the maximum regressive surface.

**Transgressive System Tracts (TST)**

The point at the rate of creation of accommodation due to relative sea-level rise exceeds the rate of sediment supply to fill the space is called the transgressive surface. Deposits on the shelf formed during a period of relative sea level rising faster than the rate of sediment supply are referred to as the transgressive system tract (TST) (Gary Nichols, 2009). The transgressive system tract is bounded by the maximum regressive surface at the base and by the maximum flooding surface at the top (Octavian Catuneanu, 2006). This system tract forms during the stage of base-level rise when the rate of rise outpaces the sedimentation rates at the shoreline. It can be recognized from the diagnostic retrogradational stacking patterns, which result in overall fining-upward profile within both marine and non-marine successions. The TST points out the relative deepening of the basin by the marine transgression.

In the coal mine area of the lower part of Yaw Formation, the transgressive system tract (TST) deposits of terrigenous sediments are trapped in the fluvial to shallow-marine transgressive prism, which includes fluvial and open shoreline. During early TST with slow rise in base-level, low accommodation space resulted in amalgamated channels with thick sheet-like sandbodies deposits as unconfined sheet floods. Periods of enhanced flood-plain aggradation, reduction of fluvial gradients may promote an evolution in channel styles to more mixed load meandering with increasing crevasse deposits. With rising sea-level, increasing accommodation space increased upward partitioning of channels and flood plain deposits at the late transgressive system tract (Fig. 3. C, D) (Fig. 4. D).

**Highstand System Tracts (HST)**

The highstand is the period of high sea level during the cycle and the beds deposited during this period are called the highstand system tract (HST) (Gary Nichols,
The highstand system tract is bounded by the maximum flooding surface at the base, and by a composite surface at the top that includes a portion of the subaerial unconformity, the base surface of force regression, and the oldest portion of the regressive surface of marine erosion (Octavian Catuneanu, 2006). During the later stages of the transgressive system and highstand phases, as rate of formation of accommodation space decreases the potential for storage and vertical accretion also declines. One result may be that more mature soils form on the floodplains (Wright & Marriott, 1993).

In Padan area, wavy bedded sandstone and lenticular bedded sandstone of delta front deposit are indicating as highstand system tracts (HST). Fining upward successions of fluvial facies association (FFA 1a) comprise planar type cross-bedded sandstone and large scale disc shape concretions were deposited during the highstand system tract. Highstand deltas are generally far from the shelf edge, and develop of delta plain and alluvial plain strata. Massive concretionary silty clay may be deposited in HST delta (Fig. 3. A-D).

**Marine bands and Maximum Flooding Surface (MFS)**

Marine bands, which bear diagnostic faunas and each marine bands overlies a coal seam or emergent, coal-prone delta plain deposits, indicating a major increase in water depth. Also, marine bands are faunal concentrate horizons with a lithological and geochemical signature implying slow, condensed sedimentation (Bloxham & Thomas, 1969). Collectively, these characteristics suggest that marine bands represent condensed sections at maximum flooding surfaces (Hampson et al., 1997). Maximum flooding surface (MFS) is marine flooding surface separating the underlying transgressive system tract from the overlying highstand system tract. The maximum flooding surface caps the transgressive system tract. This surface also marks the deepest water facies within a sequence. The maximum flooding surface represents the last of the significant flooding surfaces found in the transgressive system tract and is commonly characterized by extensive condensation and the widest landward extent of the marine condensed facies. In a progradational of farther basinward; overall, the rate of deposition is greater than the rate of accommodation.

The MFS coincides with maximum abundance of fossils (intense bioturbation) (Vail et al. 1991). Kidwell (1991) demonstrated that condensed sections occur at the base of the TST around flooding surfaces, around the MFS and also in the late highstand near a toplap position of strata. The MFS are recognized as the boundary between a transgressive unit, or retrogradational parasequence set and an overlying regressive unit or progradational parasequence set, represent the maximum landward extent of marine conditions (Emery or Myers, 1996).

Maximum flooding surface (MFS) is directly overlying the uppermost part of the transgressive system tracts (TST) in the lower parts of the Yaw Formation at the Padan area. The maximum flooding surfaces can be observed as intense bioturbation surfaces, black shale layers and fossiliferous horizons or shell beds (Fig. 4. B, C).
Figure (3) Sedimentary structures of during the later stages of TST and HST phases are:

(A) Wavy bedded sandstone of delta front deposit (DFFA 2) represent as highstand system tracts (HST)
(B) Delta front deposits (DFFA 2) of lenticular bedded sandstone are indicating as highstand system tracts (HST)
(C) Fining upward successions of fluvial facies association (FFA 1a) comprise planar type cross-bedded sandstone and deposited during the highstand system tract(HST)
(D) Low sand content of distal delta front deposits (DFFA 2) were deposited during early stage of sea-level fall. Thin lags of mud clasts may be observed the Late Highstand.
Figure (4) express the maximum flooding surface (MFS) of the marine condition;

(A) Type 1 sequence boundary of the conglomerate band observed between the Yaw Formation and overlying the Shwezetaw Formation, in the north eastern part of the Padan area

(B) Intense bioturbated sandstones are deposited during maximum flooding surface (MFS)

(C) Shell fragments, body fossils of a marine pelagic fauna commonly containing pectinid bivalves or a brackish water fauna and foraminifera fossils of marine band sandstone

(D) Herring-bone cross stratification may be indicated as the last flooding surface of transgressive system tract (TST)
**Figure (5)** Detailed sedimentological logs of cyclothsms E-1, E-2, E-6 (Yaw Formation) are Type 1 Cyclothsms and correlation with System Tracts and Eustatic curve. Keys to detailed sedimentological log are shown in Fig. (10).
**Figure (6)** Detailed sedimentological logs of cycloths E-3, E-7 (Yaw Formation) are Type 2 Cycloths and correlation with System Tracts and Eustatic curve. Keys to detailed sedimentological log are shown in Fig. (10).
Figure (7) Detailed sedimentological log of cyclothsms E-4 is fluvial sequence and cyclothsms E-5 is Type 3 Cyclothsms and correlation with System Tracts and Eustatic curve. Keys to detailed sedimentological log are shown in Fig. (10).
Figure (8) Detailed sedimentological log of sequence boundary O-1 and O-2 are Type 1 Sequence Boundary and correlation with System Tracts and Eustatic curve. Keys to detailed sedimentological log are shown in Fig. (10).
A. Falling Stage and early Lowstand Systems Tracts

Interpretation of Sequences and Relative Sea Level Changes

The study area, there are seven cycloths in the Yaw Formation and two cycloths in the Shwezet Formation. Three distinct types of cyclothem and type 1 sequence boundary are recognized. Type 1 cycloths are dominated by deltaic shorelines deposited during a falling stage and lowstand of sea level. Type 2 cycloths represent the lower delta plain, the falling stage and lowstand deltas. Type 3 cycloths comprise mainly upper delta plain deposits. The marine bands, widespread coals and coal seam groups that bound these three cyclothem types record abandonment of the delta system during periods of rapid sea-level rise.
The facies associations represent a variety of delta front, fluvial and delta plain environments, in the Padan area. During late highstand to lowstand, as sea-level starts to fall and it may increase the gradient of the river. This might result in more erosion upstream, increasing the sediment load. The lowstand prism gradually expands landward via fluvial aggradation and onlap. The top of all early-rise normal regressive deposits is marked by the maximum regressive surface. The Transgressive System Tracts (TST) points out the relative deepening of the basin by the marine transgression. In the coal mine area of the lower part of Yaw Formation, the transgressive system tract (TST) deposits of terrigenous sediments are trapped in the fluvial to shallow-marine transgressive prism, which includes fluvial and open shoreline. During the later stages of the transgressive system and highstand phases, as rate of formation of accommodation space decreases the potential for storage and vertical accretion also declines. One result...
may be that more mature soils form on the floodplains. In the Padan area, the lower parts of the Yaw Formation, maximum flooding surface (MFS) are directly overlie the uppermost part of the transgressive system tracts (TST). The maximum flooding surfaces can be observed as intense bioturbation surfaces, black shale layers and fossiliferous horizons or shell beds. From the above mention factors, it is reasonable concluded that most of the sediments in the Padan area were probably deposited under the delta front, fluvial and delta plain environments during Late Eocene to Early Oligocene time.

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