Sedimentology and Facies Analysis of the Early Miocene Rocks in the Eastern Part of Ngape Area, Minbu Township, Magway Region

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Abstract

The present study areas mainly focus on the sedimentology and facies analysis of the early Miocene rocks in Ngape area. The area as a whole is mainly composed of Tertiary clastic sedimentary rocks of Eocene, Oligocene, Miocene and Pliocene Formation. The research area contain the Upper Pegu Group, which can be subdivided into three formations such as Pyawbwe Formation, Kyaukkok Formation and Obogon Formation. By facies analysis, at least five sedimentary facies in Pyawbwe Formation,and seven sedimentary facies in Kyaukkok Formation From the studies of facies analysis, the study area under recent investigated are deposited in shallow marine, deltaic and tidal marine environment. These facies were deposited in prodelta, subtidal, delta front and delta plain facies association.

Key words: facies, Formation, delta

Introduction

The research area is located in the eastern part of Ngape area, Magway Region. The location map of the study area is shown in Fig. 1. The study area is characterized by rolling hills and lowland region trending with NNW-SSE direction. In the study area, the characteristic development of the surface drainage system displays mostly dendritic and sub-parallel pattern. The purpose of study is to interpret the sedimentology of the area.

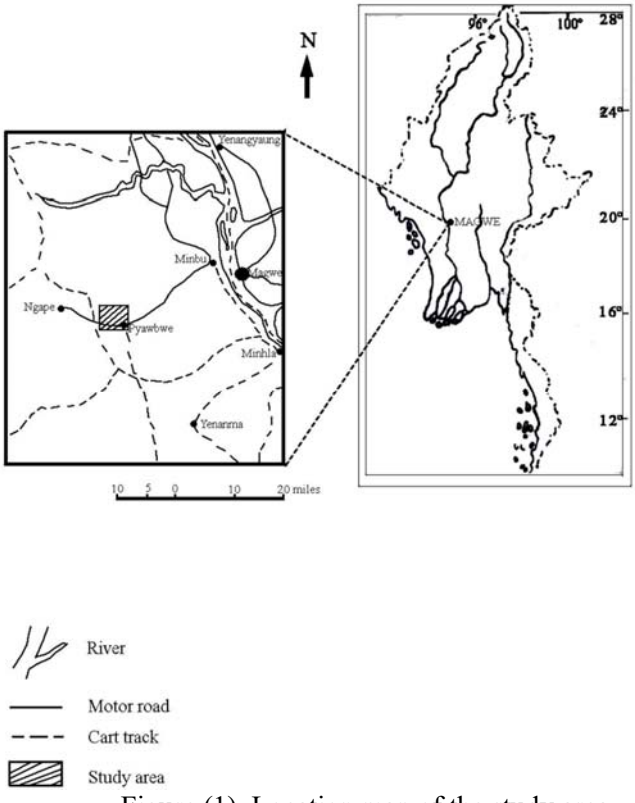

Figure (1). Location map of the study area.

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Regional Geologic Setting

Myanmar can be subdivided into four north-south trending geologic belts, namely the Eastern Highland (Shan-Tennasserim Highland), the Center Cenozoic Belt, the Western Ranges and Arakan Costal Belt (Chhibber 1934, Maung Thein 1973). The Central Cenozoic Belt is a low lying area located in Central Myanmar. The present study area is located in Minbu Basin, which include in the Inner-Burma Tertiary Basin of the Central Cenozoic Belt. The Inner Burma Tertiary Basin is mainly composed of the sedimentary infilling of Miocene, Oligocene and Eocene sequence. A small amount of Paleocene sediments are overlain by Quaternary sediments and underlain by Cretaceous rocks. The study area mainly consists of the mollassic clastic sediments of Upper Pegu group (Pyawbwe and Kyaukkok Formation). The Upper Pegu Group is unconformably overlain by Irrawaddy formation. The regional geology of the study area and it's environ is shown in Fig. 2.

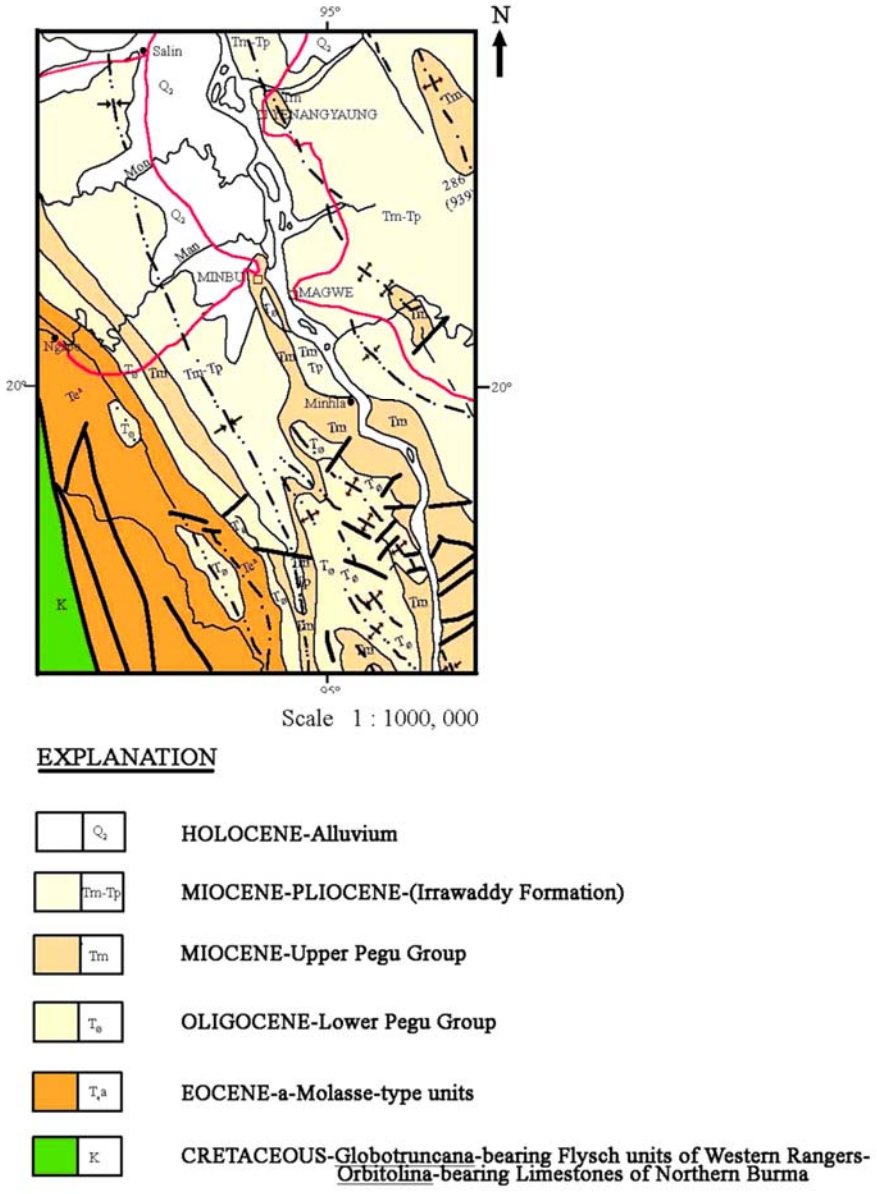

Figure (2). Regional Geological map of the study area and its environ. (After one million scale geological map of Myanmar, 1977).

Stratigraphy

The present study area is generally located in the western part of Minbu Basin (Central Basin), which lies in the Central Cenozoic Belt of Myanmar. It is mainly composed of mollassic clastic sedimentary rocks of Pegu Group (Tertiary) and Irrawaddy Formation (Miocene to Pliocene) (Fig. 3).The Pegu Group is overlain by Irrawaddy Formation with an unconformity. Pegu Group can be divided into lower Pegu Group (Oligocene) and Upper Pegu Group (Miocene). The sedimentology and facies analysis of the early Miocene rock units of the study will be discussed in detailed.

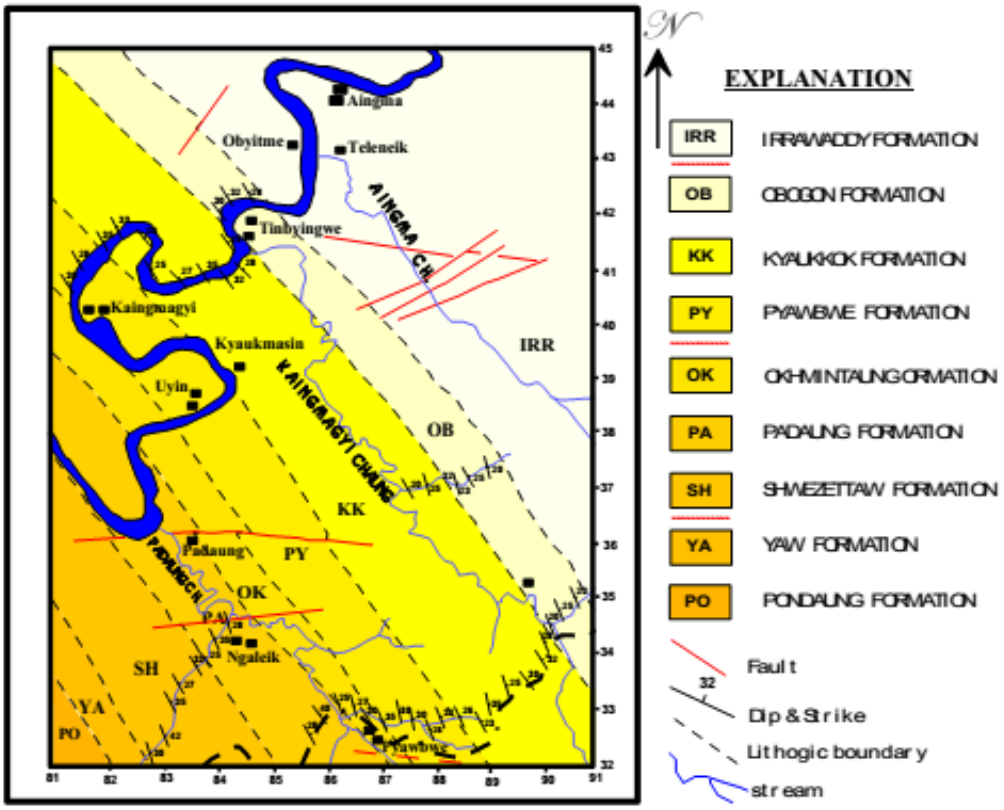

Figure (3). Geological map of the eastern Part of Ngape Area.

SEDIMENTOLOGY AND FACIES ANALYSIS

To reveal the litho facies, based on grain-size, rock type, primary sedimentary structures, paleocurrent direction, faunal contents and lithosome geometry are recorded. Lithofacies studies were carried out for the determination of the sedimentary environments of various stratigraphic unit of the investigated area.

Pyawbwe Formation

There are five lithofacies recognized, namely

(1) Thick bedded clay facies

(2) Shale with sand intercalation facies

(3) Lenticular bedded facies

(4) Cross-bedded sandstone facies

(5) Swaly cross stratified sandstone facies

Thick bedded clay facies

Description

This facies is mainly composed of thick to very thick bedded, bluish gray to light gray coloured clay Fig.4. Clay is mostly nodular to subnodular in nature. This clay intercalated with very thin lenticular fine-grained sand lenses is present. In the intercalated fine sand layers, micro-cross laminations are noticeably found. Bed base type of this facies is transitional type. Abundant microfaunas and shell fragments were observed in this unit. Bioturbation is also present in this facies. Sand-shale ratio of this facies is about 1:15. Average thickness of this facies is 3 to 8 feet. The upper part of this facies associated with shale interbedded with sand facies and the lower horizon associated with lenticular sandstone facies. This facies mainly occur in Pyawbwe Chaung.

Interpretation

The present of bioturbated sediments indicate that the depositional environment is shallow marine. Micro-cross lamination in thin sand layers characterized the storm sand layer (Reineck and Singh, 1980). The occurrence of fine-grained, thick bedded muddy sediments i.e, clay and silt clay indicate that the depositional environment is low energy condition i.e, prodelta or shelf area (Reineck & Singh, 1980). This thick bedded clay were probably deposited by suspension in low energy environment. Besides, the fine-grained sand particles were deposited under high energy environment. Due to above data, this facies can be interpreted as prodelta or shelf mud area. Moreover, this facies can be deposited when this transgression took place in the depositional site where there again have a deeper environment.

Shale with sand intercalation facies

Description

This facies is mainly composed of medium to thick bedded bluish gray shale with intercalated sand layers Fig.5. The bed base type of these shale are wave type and the sedimentary structure is lenticular continuous to discontinuous sand layer. Intercalated sand layer in shale are fine-grained, averaging 2 to 5 inches thick. Shale layer mostly upward thickening and abundant microfauna were observed in this facies. Most of sand layer are highly bioturbated. Sand-shale ratio of this facies approximately 1:5. The upper and lower horizon of this facies associated with bluish gray shale facies. This facies mainly occur in Pyawbwe Chaung.

Figure (4). Photograph showing thick bedded clay facies in Pyawbwe Formation.

Figure (5). Photograph showing shale with sand intercalation facies in Pyawbwe Formation

Interpretation

In this facies, there is no evidence for high energy condtion. Most of fine-grained sediments largely deposited by suspension and it is strongly suggested that slow sedimentation (Wright, 1986). So, the shale units were deposited in the shelf area. The present of intercalated sand layer denote that it was deposited during heavy storm. The continuous and discontinuous sand layer can be occurring between shelf and subtidal area. The area between these two area is transition zone in which storm sand layer are thicker and more numerous than shelf area. By the evidence above mentioned features, the depositional environment of this facies may be assigned as offshore transition zone.

Lenticular bedded facies

Description

This facies is mainly composed of thin to medium bedded, buff gray to light gray coloured sandstone with buff gray shales Fig.6. Bed base type of this facies is erosional type. The internal structure of sandstones is micro-cross lamination and shales are sheet nature. Sand layers are thin bedded and thinning upward character. Moreover, well developed microfauna and microboring in this unit. The thickness of each bed is 0.5 to 2 feet. This facies is vertically associated with thick bedded clay facies and cross-bedded sandstone facies. It is mainly occur in Pyawbwe Chaung.

Interpretation

These alternate beddings are mostly related to the tidal current and slack water phases (Reineck and Singh, 1980). The micro-cross lamination indicates the tidal influence. Microboring indicate a slow rate of deposition in a relatively shallow environment. Flaser bedding, lenticular bedding, wave bedding and finely sand-mud interlayering bedding are the characterized features of the mixed intertidal flat area. These facies inflect constant flucturation but relatively in a low energy condition, where coarse-sediments were transported by tidal current and waves whereas alternating fine-sediments were deposited by the suspended particles. So, this wave and lenticular bedded facies had deposited under a shallow marine, mixed intertidal flat area.

Cross-bedded sandstone facies

Description

This facies is mainly composed of yellowish to gray coloured, fine to medium grained and thin to medium bedded sandstone. Very thin layer shale also occur in this facies. The orientations of cross bedding are bidirectional and the whole unit show thinning upward character Fig.7. Cross-bedding is the main sedimentary structure of this facies. This facies contain in the upper porition of Pyawbwe Formation. The thickness of each bed is about 0.5 to 2.5 in feets. The vertically association of this facies is lenticular bedded facies and swaly cross stratified sandstone facies. This facies mainly occur in Pyawbwe Chaung and Minbu- Ngape car road.

Interpretation

Cross-bedding showing bimodal current pattern indicate that the depositional environment was influented by tidal current. The cross bedding sandstone with mud clast and shell are the essential component of channel deposits (Reineck and Singh, 1980). The burrow structures point out that the very shallow, oxygenated condition and also they are the indicative of slow rate of sedimentation. The erosional bed base of this facies indicates that erosive area and was deposited in especially channel environment.

Figure (6). Photograph of lenticular bedded sandstone facies in Pyawbwe Formation

Figure (7). Photograph of cross-bedded sandstone facies showing upward decreasing size of the cross-bedding in Pyawbwe Formation

Swaly cross stratified sandstone facies

Description

This facies is mainly composed of brownish gray to yellowish gray coloured, fine to medium-grained and thin to medium bedded sandstones Fig.8. Very low angle swaly and cross of lamination with the angle of less than 10° are also occurred. This facies is sharp and erosional bed base type. Sheet nature thin layer shale can also be seen. Each sand bed thickness is about 0.5 to 1.5 feet and thickening upward nature. The lower part of this facies associated with thick bedded clay facies and the upper part associated with cross-bedded sandstone facies. This facies occur in Pyawbwe Chaung.

Interpretation

The upward current of the sandstone beds containing low-angle cross-stratification of swaly cross-stratified can be regarded as near-shore sand bar deposits (Yuzo Katsura et al, 1984). The intercalated trough cross-stratification can also be interpreted as the scoops of bar crest by wave orbital current (Davision et al, 1976). The swaley cross-stratification represented at the upper part of this facies can be referred to as a storm sheet sand deposited in the shoreface to offshore area. These shallow swales are related to increased wave energy (Harms, 1975).

Figure (8). Photograph of swaly cross-stratified sandstone facies in Pyawbwe Formation.

The upper part of this facies seems to have formed by the fine sand under a fair weathered condition. Reading (1981) and Wright (1986) suggested that medium to coarse-grained sediments with high energy bed forms and internal structures characterized the lower shore face (or) subtidal area as depositional environment. Over all sequence examined, the influential tidal current features and storm induced coastal flows of the shelf lower off shore area (Reading, 1981).

Kyaukkok Formation

Seven lithofacies recognized in Kyaukkok Formation, they are
(1) Lenticular bedded facies
(2) Sandstone interbedded with shale facies
(3) Trough cross-bedded sandstone with mud clast facies
(4) Sigmoidal cross-bedded sandstone facies
(5) Bioturbated muddy sandstone facies
(6) Ripple sandstone facies
(7) Shale dominant facies.

Lenticular bedded facies

Description

This facies is mainly composed of sand-mud interlaying bedding. The different sedimentary structures such as sand-shale interlayers, flaser and lenticular bedding are also present Fig.9. In some sandstone, the small scale cross-bedding and micro-cross lamination can be occurring. Bed base types are erosional type and sometime wavy base types are remarkable. Both microfauna and shell fragments are observed in this facies. The thickness of each bed is 0.5 to 2 feet. This facies is vertically associated with sandstone interbedded with shale facies and trough cross-bedded sandstone with mud clasts facies. Lenticular bedded facies was measured from Man Chaung and Kaingmagyi Chaung.

Interpreation

Reineck and Singh (1980) and Klein (1970) proposed that flaser bedding, lenticular bedded, wavy bedding and finely interlayered sand-mud bedding are the characterized features of the mixed intertidal flat area. The alternate bedding are mostly related to the tidal current and slack water phases (Reineck and Singh, 1980). In other process, these sand and mud layers characterized the current activity and slack water period respectively. These facies reflect constant flucation but relatively in a low energy condition, where coarse sediments were transported by tidal current and wave where as alternating fine sediments are deposited by the suspended particles. So, this facies had deposited under a shallow marine, mixed tidal flat area.

Sandstone interbedded with shale facies

Description

This facies is mainly composed of reddish brown to brownish coloured sandstone interbedded with buff gray coloured shales Fig.10. This facies is erosional bed base type. The internal structure of sand bed, the micro-cross lamination and micro cross-bedding are also present. Shale layers are intercalated in sand beds. In the lower bed of this facies, the vertical burrow structure can be seen. Average thickness of this facies is 2 to 6 feets. The thickness of each sand bed is about 0.5 to 10 inch and the thinning upward nature also exists. Sand-shale ratio of this facies is 5:1. This facies is vertically associated with trough cross-bedded sandstone with mud clast facies and shale dominant facies. Sandstone interbedded with shale facies main occur in Kaingmagyi Chaung.

Interpretation

The fine-grained sands are found when flood water with fine-grained sediments indicate over the bank. The shale layers are deposited by suspension in low energy environment. At the time of active wavy condition, the transportation of fine sand particle may be caused wavy lamination. At the time duration of flooding is so long, the sand beds are more abundant than shale layer. Therefore, fine grained materials deposited in this facies assumed to be the level deposits (Reineck and Singh, 1980). The depositional site of this facies can be interpreted as the overbank deposits of fluvial environment.

Figure (9). Photograph of lenticular bedded sandstone facies in Kyaukkok Formation.

Figure (10). Photograph showing sandstone interbedded with shale facies in kyaukkok Formation.

Trough cross bedded sandstone with mud clast facies

Description

This facies consists of fine to medium, medium to coarse-grained, buff to yellowish gray coloured and medium to thick bedded sandstones. In these sandstone mud clasts, mud pebbles and shell fragments are present. Muds pebbles vary from 0.3 to 2 inches in diameter are present Fig.11. This facies is characterized by erosional and wave bed base type and medium to large scale cross-bedding are major sedimentary structure. Besides, the middle parts of this facies rapple mark are also common. The thickness of this facies varies from 1 to 5 feets. Trace fossil and shell fragments are observed in this unit. The upward of this facies associated with lenticular bedded facies. This facies mainly occur in Man Chaung and Kaingmagyi Chaung.

Interpretation

The trough cross-bedded sandstone with mud pebbles and shell fragments are the distinct features of the channel leg deposits (Reineck and Singh, 1980). The present of the bidirectional cross-bedding is the indicator of the tidal current facies and formed under high energy environment. The content of mud clast increase in the lower part of this facies. The features of wave or erosional bed base types and the present of mud clasts were deposited in tidal channel or intertidal flat. Abundant mud pebbles can be interpreted as channel floor deposits. Mud drapes observed along the plane of cross-bedding reflect the suspension in the slack water pahse. Therefore, this facies may be regarded as challel deposits or delta plane environment.

Sigmoidal cross-bedded sandstone facies

Description

This facies is mainly consisted of brownish gray to gray coloured, fine to medium-grained and medium to thick bedded sandstone. Bed base types of this facies are erosional and wavy type in character. The sedimentary structure such as sigmoidal

cross-bedding and medium scale trough cross bedding are remarked in this facies. The ripple showing the reverse flow direction also exists on the cross-bedded horizon Fig.12. A few mud drapes also concentrated at the base of facies. The sigmoidal cross-bedding sets are bounded by mud drapes. The upper portion of this facies associated with lenticular bedded facies and the lower portion associated with sandstone interbedded with shale facies. This facies can be occur in Man Chaung and Kaingmagyi Chaung.

Interpretation

The sediments of this facies is deposited during flood and the rate of sedimentation is very high energy. The present of unidirectional trough cross-bedding are the indication of one directional storm current effected facies. The sediments were assumed to be deposited under the high energy environments. The mud drapes encased in cross-bedded sets are pause plain or slack water indicator of the tidal bundies. (Kraisa and Moiola,1986). Most of the sigmoidal cross-bedding displays paleocurrent direction landward. Due to above data, the sigmoidal cross-bedding sandstone facies was deposited in subtidal channels.

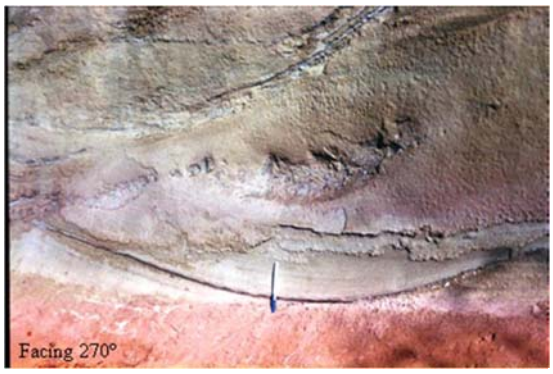

Figure (11). Photograph of through cross-bedded sandstone facies in Kyaukkok Formation.

Figure (12). Photograph showing sigmoidal cross-bedded sandstone facies in Kyaukkok Formation

Ripple sandstone facies

Description

This facies is mainly consisted of fine to medium-grained, greenish gray to gray coloured, thin to medium bedded sandstone. This facies is erosional bed base type and small-medium scale ripple marks are also present Fig.13. Ripple mark and micro cross-lamination are the main sedimentary structures showing bidirectional current activity. The thickness of this facies is about 1 to 3 in feet. The vertically association of this facies is shale dominant facies and sandstone interbedded with shale facies. This facies is mainly observed in Man Chaung and Kaingmagyi Chaung.

Interpretation

Small-medium scale ripples are also occurred by ebb or flood current activites with low energy (Klein, 1970). In this facies, the sedimentary was formed by wave and curry action. And them, bidirectional foreset bed point out that tidal current prevealed in this facies. The wave

lamination and ripple mark reflect strong, bottom current during high energy condtion. Some mud drapes are deposited along the trough of ripple during low energy. By the evidence of above mentioned characteristics, the depositional environment of this facies can be regarded as intertidal flat or sandflat area.

Bioturbated muddy sandstone facies

Description

This facies is mainly composed of medium to coarse-grained, medium to thick bedded, brownish gray to gray coloured muddy sandstone Fig.14. Bed base type is erosional type in nature. The internal structures of this facies are medim scale trough cross-bedding and herring-bone cross-bedding. Inclination of cross-bedding is 40' and thinning upward character. The bioturbations structures are vertical and horizontal burrows. The thickness of this facies is 2 to 5 feets. The upper horizon of this facies is associated with lenticular bedded facies and the lower horizon is associated with ripple sandstone facies. This facies mainly occur in Man Chaung.

Interpretation

The occurrences of bioturbations structure indicate the very shallow oxygenated and also they are indication of slow rate of sedimentation. The trough cross-bedding showing the bimodal current patterns indicate that the depositional environment was covered by tidal action. Moreover, the bioturbations zone in the intertidal area is the sand flat. Depending on the vertical sequence, this could represent flucturation in current intensity. The bioturbations nature indicates poorly sorted sand-mud in depositional site where nutrient rich condition prevailed (Reineck and Singh, 1980). The depositional environment of this facies may be interpreted as shelf or tidal offshore area.

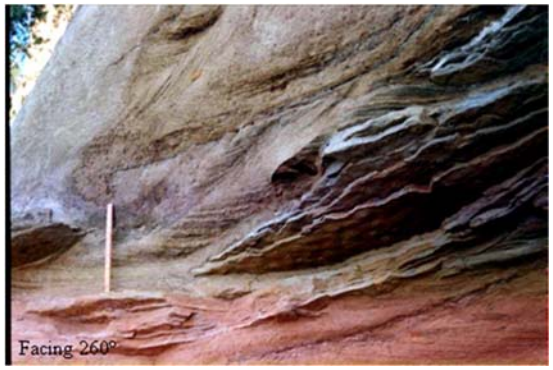

Figure (13). Photograph ripple sandstone facies in Kyaukkok Formation

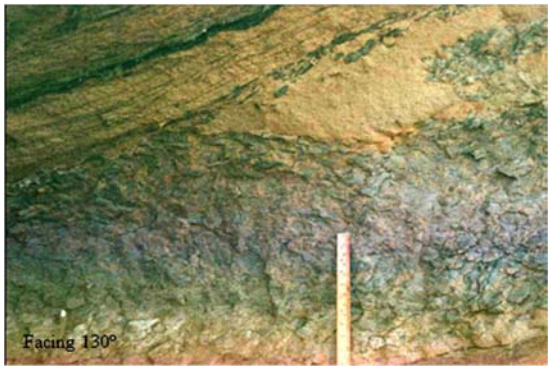

Figure (14). Photograph showing the typical nature of mottled horizon in Kyaukkok Formation

Shale dominant facies

Description

This facies is mainly composed of medium to thick bedded and bluish gray coloured shale characteristics Fig.15. The sedimentary structure is micro cross-lamination in associated sand lens and transitional bed bas type is well remarked. The thickness of this facies is 3 to 10 feet. Microfauna and shell fragment are observed in this unit. Bioturbation horizons are to be observed. The vertically of this facies is associated with trough cross-bedded sandstone with mud clast facies. This facies is mainly occurring in Man Chaung and Kaingmagyi Chaung.

Interpretation

The possible depositional place of this muddy sediments in the intertidal zone is the muddy intertidal flats near high water line (Reineck and Singh, 1980). Because wave and current energy decrease shoreward in intertidal zone, mud deposition occurs near high tide. Intercalated sand lens with bidirectional micro-cross lamination were formed by the tidal current and wave activity (Klein, 1970). But the evidence of above mensioned characterized the depositional size of this facies can be matched with intertidal mud flat or muddy intertidal flat area.

Figure (15). Photograph of shale dominant facies in Kyaukkok Formation.

Facies association

The each facies can point out a process of deposition rather than depositional environment. Therefore, these facies should grouped facies association. In the present study area, four facies association can be observed Fig.16,

(1) Delta plane facies association
(2) Delta front facies association
(3) Subtidal facies association
(4) Prodelta/Off shore facies association.

This facies association are superimposed each other by the control of sea level changes, sediment availability and basin tectonic.

Delta plane facies association

Cross-bedded sandstone facies of, trough cross-bedded sandstone with mud clast facies of Pyawbwe and Kyaukkok Formation were deposited in channel, point bar and delta plane environment respectively.

Abundant channel leg deposits at the base of the sand bodies with erosional contacts with the underlying marine shale unit can be interpreted as the base of an incised-valley system of the estuary environment (Allen and Posamentier, 1993).

Vertical facies relationships of the mixed-flat facies indicate that tidal meander channels in a tide-dominated estuary environment prevailed in association with early trangression.

Vertical relationship of facies and paleocurrent directions are also interpreted as representative of an alternation of ebb currents and flood currents in the central, mixed-energy (meandering) and inner, river-dominated portion of the estuary environment (Dalrymple et al, 1992).

Delta front facies association

Lenticular bedded facies of Pyawbwe Formation, ripple sandstone facies, lenticular bedded facies and shale dominant facies, and trough cross bedded sandstone with mud clast facies, lenticular bedded facies of Kyaukkok Formation can be grouped as a lithofacies association named intertidal facies association.

The sand/mud interlaying bedding types are especially well developed in the cross bedding of point-bar deposits of shallow tidal channels (Reading, 1986). This alternating bedding character is mostly related to the alternation of tidal current and slat water phases (Vos, 1977; Reineck and Singh, 1980). The interlaminated mud, silt and sand exhibit prolific flaser, wavy and lenticular beddings mainly dominated in intertidal flat environment.

Furthermore, flaser-bedding sand and silt and lenticular bedding sand and clay indicate the mixed-flat environment (Reineck, 1972, Reineck and Singh, 1980). Parallel limanited fine sand is interpreted as the sand flat of the upper flow regime in an intertidal environment.

Subtidal facies association

Sigmoidal cross-bedded sandstone facies and herringbone cross-beddes sandstone facies of Kyaukkok Formation can be grouped into this facies association.

This facies association appears to have been deposited in the subtidal zone of the second transgressive period in an estuary environment. The bidirectional cross-sets and sigmoidal bedding are similar to feature recorded in tidal-influenced settings (Kreisa and Moiola, 1986; Pattison, 1955; Rossetti, 1998). Bidirectiona ripple marks on the top of the sequence indicate over bank deposits of tidal origin with repeated alternation of current and flood periods (Mackenzie, 1975).

Prodelta / off shore facies association

Thick bedded clay facies and shale with sand intercalation facies of Pyawbwe Formation, sandstone interbedded with shale facies and bioturbated muddy sandstone facies and sand-shale interbedded facies of Kyaukkok Formation can be group into prodelta/shelf facies association, which represent an area where these sediments were deposited.

Thick bedded clay and fine-sand indicate that the depositional environment is relatively low energy environment. The micro-cross lamination sandstones are the storm sand layers (Reineck and Singh, 1981).

The land-ward transition to finer-grained deposits overlying this facies association also supports this interpretation and may reflect a transitional, wide marine-influenced mouth of an estuary (Reineck, 1972, Reineck and Singh, 1980, Hettinger et al, 1992). The close association of the bioturbated sand and mud intercalations, suggest tidal environment (Reinson and Hettinger, 1992; Rossetti, 1998).

The intercalated sand layer are emerged by storm surged ebb current, particularly (Reading, 1980), and the typical coarsening upward sequence reflect that the shore line had prograded across the muddy shelf.

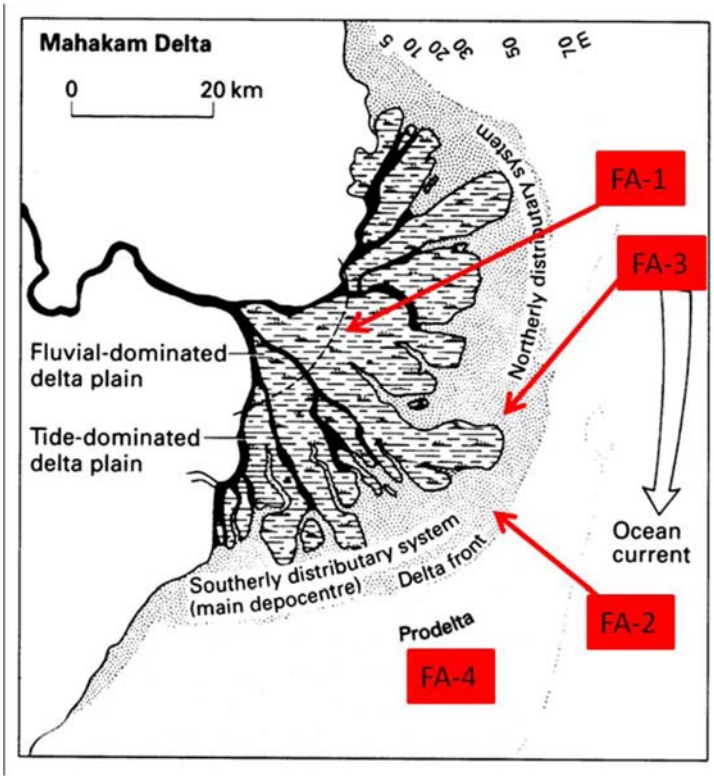

Figure (16). Generalized lithofacies association in fluvial tide-dominated deltaic model of Upper Pegu Group.

Sedimentation History

The study area occupies the Pyaw and Kyaukkok Formation of early Miocene stratas of the eastern part of Ngape area compare major marine transgression and regression of different orders. During Early to the initial of middle Miocene period are transgression-regression cycle is occurred. The study succession is composed of three major stratigraphic units of Miocene period deposited in transgression-regression cycle. From the facies analysis, The Pyawbwe Formation was deposited in shallow marine environment and the Kyaukkok Formation was deposited in deltaic and tidal marine environment.

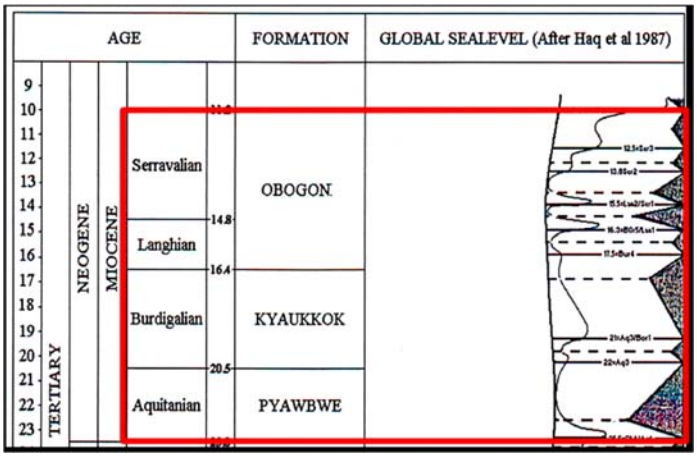

Figure (17). Global eustatic sea-level curve of Haq et al. (1988) related to the Upper Pegu Group fall the second order to third order eustatic time.

The major deposition of early Miocene strstas was initiated by marine transgression (early Miocene) followed by the major regression condition in the beginning of middle Miocene Fig.17.

Summary and Conclusions

The study area is located in Minbu Township, Magway Region. The study area situated in the western part of Minbu Basin, include in the Inner-Burma tertiary Basin of the Central Cenozoic Belt. The study area mainly consists of the clastic sedimentary rocks of Pegu Group (Oligocene-Miocene). Pegu Group is divided into Upper Pegu Group and Lower Pegu Group by an unconformity which occur at Oligocene / Miocene boundary.The Upper Pegu Group can be subdivided into Pyawbwe, Kyaukkok and Obogon Formation. Pyawbwe Formation mainly consists of bluish colored clays with minor amount of yellowish brown sandstone. The age of the formation is early Miocene. Kyaukkok Formation mainly comprise of yellowish to brown colored, medium to coarse-grained, thick bedded to massive sandstone. The age of this formation is early Miocene. In Pyawbwe Formation five lithofacies can be recognized and in Kyaukkok Formation, which have seven lithofacies. From the facies analysis, the Pyawbwe Formation was deposited in shallow marine environment. The Kyaukkok Formation was deposited in deltaic and tidal marine environment. Therefore, the area enter recent investigation have been subjected by marine transgression and Aquitanian, which was followed by the regressive condition in Burdigalian and trangress again in the end of early Miocene time.

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