SEDIMENTARY FACIES ANALYSIS OF EARLY EOCENE UNITS IN THE NORTHERN MINBU BASIN

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Abstract

The present study mainly focuses on the Sedimentary facies of Clastic sedimentary rock mainly on the sandstones of Early Eocene. Early Eocene unit exposed in the northernmost part of the Minbu Basin, Tilin Township, Magway region. The study attempts to determine their depositional environment. The study area mainly consists of Tertiary Clastic Sedimentary rocks. The strata can be classified into two major stratigraphic units such as (1) Laungshe Formation (Early Eocene) and (2) Tilin Formation (Early Eocene). The stratigraphic sections of the study area were measured by Jacob staff methods. The lithology, texture, sedimentary structure, fossils content and tectonic deformation will be checked and recorded. Lithologically, Laungshe Formation is mainly composed of thinly laminated dark grey to bluish grey shale intercalated with thin to medium-bedded sandstones. Tilin Formation is mainly composed of sandstone. Early Eocene units are divided into nine lithofacies. Based on the lithofacies and characteristics, at least (3) lithofacies associations can be established in the Early Eocene clastic strata of the research area. These are (1) Prodelta association (2) Delta front association and (3) Delta top association. Based on sedimentary lithofacies and facies association, the depositional environment of Laungshe Formation is shallow marine environment and the depositional environment of Tilin Formation is deltaic environment. Thus, the depositional environment of Early Eocene units is deltaic to shallow marine environment.

Keywords: Facies, Prodelta, Delta, Depositional Environment

Introduction

The research area, northernmost part of the Minbu Basin, is located at 16 km east of Tilin, Magway region. It lies between latitudes 21˚ 36′ N and 21˚ 44′ N and longitudes 94˚ 09′ E and 94˚ 17′ E in UTM-No 2194-02 and 2194-06. The location map of the study area is shown in figure (1). The research area is a mountainous and forested region and the ranges are running north-south direction. Because of the sandstone dominant and shale dominant formation, this area shows ridge and valley topography. It lies between Pondaung range and the eastern flank of the Chin hill. The strata can be classified into two major stratigraphic units such as (1) Laungshe Formation (Early Eocene) and (2) Tilin Formation (Early Eocene).

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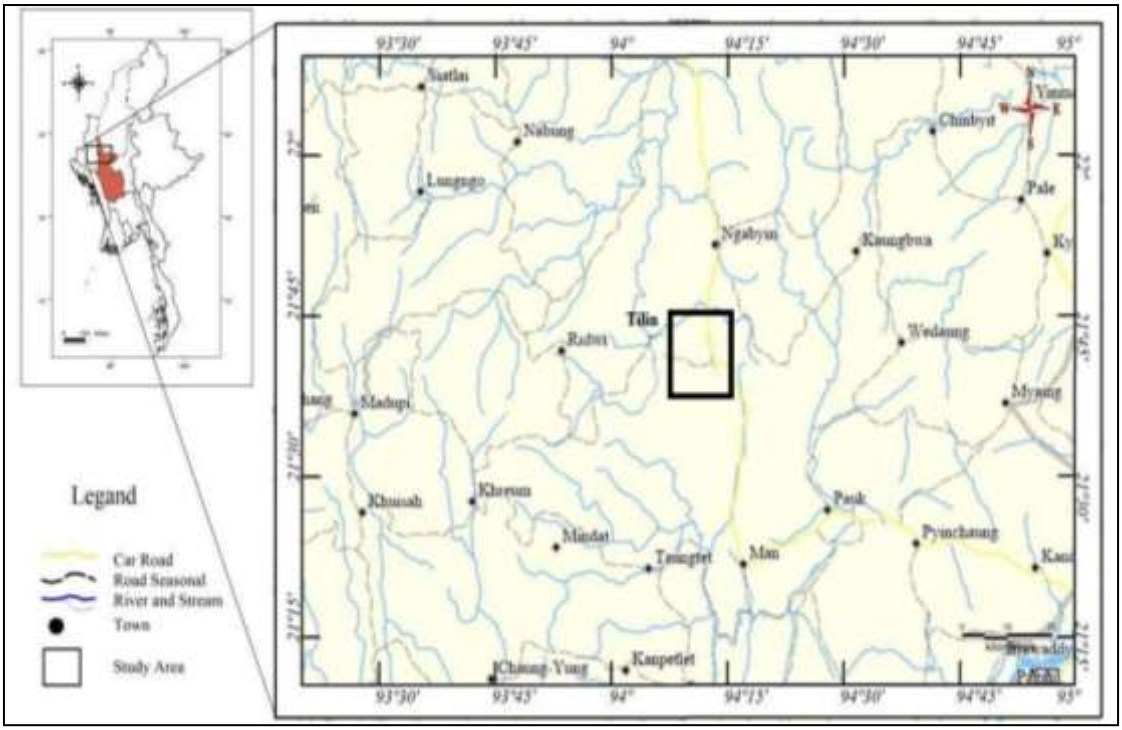

Figure (1) Location map of the study Area

Methodology

Field method-detailed sedimentological measurement was carried out from stream sections and road cuttings. The stratigraphic sections of the study area were measured by Jacob staff methods. The field work is to collect require stratigraphic record from the outcrops of the study area for the establishment of the detail stratigraphic framework and to collect samples for laboratory analysis. The lithology, texture, sedimentary structure, fossils content and tectonic deformation will be checked and recorded.

Geological Background

The present study area is situated in the northern part of the Minbu basin in Central Cenozoic Belt where Mesozoic and Tertiary rocks exposed. The Minbu Basin is bounded on the east by a major strike-slip fault, Sagaing Fault and on the west by western ranges. The regional trends of the mountains run generally north-south with slight variations in some places.

The Minbu Basin is bounded by a couple of 20˚ N and 22˚ N uplifts. Structurally, Minbu Basin is a south plunging Syncline (Salin Syncline), measuring approximately 200 km in length, north south oriented and about 70 km in width.

The name “Laungshe Shale” was first introduced by Cotter (1915) after Laungshe village (20˚ 02′ N - 94˚ 03′ E) for a sequence of thin bedded claystones, siltstone underlying the Tilin Sandston. It comprises the alternating beds of sandstone and shale or clay which are ranging in Early Eocene age. They are generally north-south trending. In 1969, Aung Khin and Kyaw Win used the name “Laungshe Formation” as a formal lithostratigraphic unit.

Laungshe formation is mainly composed of thinly laminated dark grey to bluish grey shale intercalated with thin to medium-bedded sandstones. The lower boundary between Paunggyi Formation and Laungshe Formation observes the comformable contact. The upper boundary with overlying Tilin Formation is comformable. It is gradational contact along most of its extent. This formation was considered as Early Eocene age on the basic of fauna contents.

The name "Tilin sandstone" was first introduced by Cotter (1915) after Tilin village (20˚ 45′ N - 94˚ 06′ E) for a sequence of grey to yellowish brown sandstones and some thin bedded clay which exposed in the area between Milestone 75 and 81 on the Pakokku-Tilin road. They are generally north-south trending. In 1969, Aung Khin and Kyaw Win used the name "Tilin Formation" as a formal lithostratigraphic unit.

Although Tilin Formation is mainly composed of sandstone, it seems to be subdivided into two members; a lower and upper according to sand/shale (clay) ratio. The lower boundary between Laungshe Formation and Tilin Formation observes the comformable contact. It is fairly sharp boundary along car road from Anayban to Kyin village. The upper boundary with Tabyin Formation is transitional contact. The faunal assemblages and its stratigraphic position indicate the Early Eocene age for this unit.

Sedimentary Lithofacies Analysis

A number of good outcrops of Early Eocene units are situated especially along Tilin-Pakokku car road sections. The stratigraphic section of Early Eocene Formations is measured along the Tilin- Kyin- Pauk car road sections. The lithology, texture, sedimentary structures, fossils contact and tectonic deformation were checked and recorded during measurement (Graham, 1988). Base on stratigraphic measured section, Early Eocene Formations are 2114m thick. Based on the characteristic of sedimentary units which include thickness, sedimentary structures, grain sizes and types, colour and biogenic contact of the sedimentary rock, the lithofacies of Early Eocene units are classified. Early Eocene units are divided into nine lithofacies. Measured sections are described in figure (2).

Thin-lenticular bedded sandstone facies

This facies is well developed in the lower and middle parts of Tilin Formation. It is consists of dark grey in the weathered surface, dark brown and yellowish brown in the fresh surface, fine to coarse grained and very thin to thin bedded sandstone (figure 3). Pelecepods fossils are locally occurred in this facies. Sedimentary structures are characterized by liguide ripple (figure 4), mud crack, burrow structure, parallel lamination, cross bedding, lenticular bedding, concretion, load cast, flute cast and mud pebble. Recorded maximum thickness of this facies is upto 13 meters. The upper boundary is gradational contact to very thin to thin bedded shale facies.

This facies reflects the seaward of the distributary mouth bar in seaward sloping margin of the delta front environment where the sedimentation rate is high. The sedimentary structures association in the deposit of this facies such as cross bedding, ripple mark and lenticular bedding are interpreted to the deposit of delta front area. The repeated occurrence of the definite sequence of the sedimentary structures indicates the seasonal layering (Reineck and Singh., 1980). The dimension of the sand beds of this facies show the sheet like deposit, which means the delta front sheet sand. Thus, this facies can be interpreted as delta front environment.

Massive sandstone facies

This facies is well exposed at the upper part of Tilin Formation. It is consisted of medium to coarse grain and massive sandstone (figure 5). In this outcrop, this sandstone appears grey in weathered surface, greenish grey in fresh surface well marked. The sedimentary structures such as parallel lamination and mud pebble (figure 6) are noted. Sandstone with mud pebble at the base on erosional surface is overlain upon the bluish grey shale with erosional contact.

Figure (2) The explanation of the stratigraphic column of Early Eocene Units

Figure (3) Brown, fine to medium grained and very thin- to thin-bedded sandstone of Laungshe Formation

Figure (4) Current ripples developed in thin bedded sandstone at the lower and middle part of Tilin Formation

Massive bedding and medium- to coarse-grained indicated that very high energy channel area. This facies is generally interpreted to have been formed in channel environment.

Figure (5) Grey, medium- to coarse-grained, massive sandstone facies of the Tilin Formation

Figure (6) Mud pebble in massive sandstone of the Tilin Formation

Mudstone facies

This facies is well developed in the middle part and upper part of Laungshe Formation and lower part of Tilin Formation. Mudstone facies is consists of light brown in the weathered surface, light grey in fresh surface (figure 7). Mudstone is intercalated with light grey shale. These facies contain abundance horizontal burrow structures (figure 8). The average thickness of this facies is 14 m thick. The upper contact is sharp to very thin to thin bedded sandstone facies.

Horizontal burrow structure indicated low energy and quite water environment. The very fine to fine-grain composition and laminated structure of this facies is indicative prodelta deposition. Laterally extensive shale and mudstone lamination is deposited in prodelta (Reineck and Singh, 1980).

Figure (7) Light brown, thin-bedded mudstone of Laungshe Formation

Figure (8) Horizontal Burrow structure in brown, thin-bedded mudstone of Laungshe Formation

Grey shale facies

This facies is widely distributed throughout the whole unit of Laungshe Formation and Tilin Formation. It is mainly consists of dark grey in weathered surface, light grey in fresh surface, very thin to thin bedded shale (figure 9). Thin and parallel laminated structure are characterizes in shale bed. Mud concretion, caliche and gypsum plates (figure 10) are found in this facies. The thickness of this facies is varies from 10 meter to 15 meters. The upper boundary is gradational contact to sandy shale facies.

Very fine grain interpreted that suspension sediments deposited in low energy area such as prodelta of shelf. This facies is interpreted to be of prodalta or shelf environment. Thick finer sediments and intercalated marl band show quite water, low energy condition. The fine- grained muddy sediments are the prodelta deposits, which are closely related to prograding deltaic system (Reineck and Singh, 1980).

Figure (9) Dark grey, very thin- to thin-bedded shale of Laungshe Formation

Figure (10) Gypsum plates intercalated in dark grey, very thin to thin bedded shale of Laungshe Formation

Carbonaceous or coaly shale

This facieses well developed at the middle part of Tilin Formation. It contains coaly shale with thin siltstone and dark grey to black carbonaceous (figure 11). In this facies, coal layer apparent 20 cm in the embedded in brownish shale is well marked. The coal layer is thinning to eastward at the measure section.

The formation of coal is in the swamp, flood basin of the area where the thick accumulation of plant remains formed into the coal layer. The siliciclastic input is very least in this and also represent to the emergent of the area. Therefore, this facies is interpreted to be deposited in a swampy environment or delta top.

Sandstone intercalated with thinly shale

It is well developed at the lower and middle part of Tilin Formation. It is consisted of fine to medium grained, thin to medium bedded sandstone (figure 12) dark grey in the weathered surface, dark brown and brown in the fresh surface. Sandstone is intercalated with grey and dark brown, thinly bedded shale. Leaf imprint are observed in this facies. Mud pebbles and ripple marks occur in this sandstone. The maximum thickness of this facies is 9 meters. The lower contact is gradational contact to medium bedded sandstone. The upper boundary is sharp with very thin to thin bedded shale.

This facies includes several exclusive features of tidal deposits. Sandy sediments in parallel stratification are observed in intertidal zone of tidal influence coastal regions (Nichols, 1999, 2009). This facies is interpreted as forming from alternating flood-ebb tidal current with intervening slack-water suspension fallout in tidal flood area (Miall, 2000).

Figure (11) Carbonaceous or coaly shale of the Tilin Formation

Figure (12) Grey, fine- to medium- grained and thin to medium bedded sandstone intercalated with dark brown shale

Swaly cross stratified sandstone facies

This facies is well exposed at lower and middle part of Tilin Formation. It is consisted of fine to medium grain, thin to medium bedded sandstone (figure 13). Plecepods fossils fragment occurs in this facies (figure 14). Sedimentary structures are characterized by mud concretion, parallel lamination and mud crack. The maximum thickness of this facies is 3 meter. The lower boundary is gradational contact to very thin to thin shale facies. The upper contact is gradational to very thin to thin sandstone facies.

This facies was deposited in shallow marine subtidal area under storm condition. This facies developed lower the delta front deposits and covered by medium to thick bedded sandstones of mouth bar deposits. Swaly cross stratification is believed to form as a result of combined flow that is the action of both waves and a current (Nichols, 2009). Base on bedding character, this facies is the lower part of mouth bar deposits in the delta slope environment (Reading, 1996) or lower subtidal depend upon storm period.

Figure (13) Swaly cross stratified sandstone facies of Tilin Formation.

Figure (14) Fossils fragment collected from shale intercalated with sandstone facies

Sand and shale interbedded facies

This facies is well exposed at the middle part of Tilin Formation. It is consisted of fine grained and thin bedded sandstone, reddish brown in weathered surface, light grey in fresh surface. Sandstone mostly possessed laminated nature alternate with grey shale (figure 15). The thickness of this facies is 2.5 meter. The lower contact is gradational to very thin to thin bedded sandstone. The upper contact is sharp to medium bedded sandstone facies.

Sharp contact between sandstone and shale layers is the typical features of tidal process and identified as tidal rhythmic (Reineck ad Singh, 1980). The sand-shale interbedded can be interpreted by the deposition of tidal current and slack water conditions respectively during flood and ebb current activities (Nichols, 1999, 2009).

Thick-bedded sandstone facies

This facies is well developed in the upper part of Tilin Formation. It is composed of dark grey in the weathered surface, dark brown and yellowish brown in the fresh surface, thick to very thick bedded and fine to medium grained micaceous sandstone. Sedimentary structures such as by very low angle cross bedding and parallel lamination (figure 16) are noted. Thickness of this facies is ranging from 0.5 to 21 meter. The lower contact is gradational with very thin to thin bedded shale facies. The upper boundary is sharp to massive sandstone facies.

This facies is vertically associated with the bedded shale facies and massive sandstone facies. Sedimentary structures contained in this facies indicate the where influence high-energy current such as planar cross-bedding. The sedimentary structures pointed to tidal condition in this facies. The lithology characters and sedimentary structures interpreted that this facies is the deposits of high energy current in tidal flat in subtidal sand body,

Figure (15) Sand and shale interbedded facies of the Tilin Formation

Figure (16) Thick to very thick bedded sandstone showing parallel lamination in the Tilin Formation

Facies Associations

In clastic facies analysis, individual facies are process related and are usually not environmentally specific. Facies associations are environmentally specific. Therefore, in clastic facies analysis, individual processes (facies) are needed to be combined together into facies associations to define environment. Based on the lithofacies and characteristics, at least (3) lithofacies associations can be established in the Early Eocene clastic strata of the research area. These are (1) Prodelta association (2) Delta front association and (3) Delta top association.

Prodelta facies association

The prodelta facies association consists of grey shale facies and mudstone facies in the study area. The prodelta is the area of low energy environment, where thick accumulation of finer particals settles out from suspension.

In the study area, this facies association occupies the lower and middle part of the Laungshe formation and lower part of Tilin Formation of the eastern part of the study area. This lithofacies association is mainly composed of lamination shale, thin- to medium-bedded mudstone, and very fine- to fine-grained sandy shale. Thin and horizontal laminated structures are common in the sediments of this association. Very fine- to fine-grained of suspended materials and marine fauna of this lithofacies association indicated prodelta deposits (Reading, 1996; Blatt *et al*, 1980).

Delta front facies association

Delta front facies association mainly consists of thick-bedded sandstone, thin-lenticular bedded sandstone and sandstone intercalated with thinly shale. In the study area, Laungshe Formation and the lower and middle part of Tilin Formation mostly occupy the delta front sheet and sand-mud alternate bedding. These facies associations are always developed over the sediments of prodelta association. This lithofacies association includes fine- to medium-grained, thin- to thick-bedded sandstone intercalated with shale. Medium- to thick-bedded sandstones are characterized by thickening upward bedding and coarsening upward grain. Cross bedding are occurred in these sediments. The lithologic and bedding character of this association is representation as the coarsest grains are deposited at the mouth bar and finer away from mouth.

Based on these characters, the sediments of this association are deposited in delta front environment (Nichol, 1999, 2009).

Delta top facies association

Delta top facies association mainly consists of sand and shale interbedded facies, massive sandstone facies and carbonaceous coaly shale facies. In the study area, this facies association occupies the upper part of Laungshe formation and Tilin Formation of the eastern part of the study area. The deposition of cross -bedded sandstone with mud drape is typical delta deposits which is always association with coal of swampy area.

This lithofacies association contains massive sandstone, and alternated layer of thin-bedded sandstones and very thin- to thin-bedded shale. The coarsest material is the evidence of fluvial processes is the representative of river channel deposits in delta top setting (Reading, 1996). Sand-shale alternation also showed ebb-flood currents with intervening slack-water suspension deposition in delta top environment (Nichols, 1999, 2009).

Depositional Environment

The lithofacies associations and their possible environments have been discussed. The interpretations are in agreement with those mentioned by Walker *et al* (1992), Reineck and Singh (1980), and Reading (1996). The environments are classified into three major groups; prodelta, delta front and delta top.

The lower part of Laungshe Formation is started the beginning of channel deposition in continental shallow shelf during regression by the occurrence of very coarse grained sediments. These regressive sediments are followed by the very fine grained sediment of shale, mudstone and transgression was started. This sequence is the evidence of world-wide sea level rise during the early Eocene. These fine grained sediments are deposited in prodelta environments. The prodelta sediments are covered by the delta front sediments of thin-bedded sandstones, thickening upward sandstone intercalated with shale and coarsening upward mouth bar deposits. The fining away and downward sediments are deposited in delta front environment. These trangressive sediments are developed in the middle part of Laungshe Formation. The marine transgression is terminated by the redeposition of delta front sediments and prodelta sediment successively. The upper portion of Laungshe Formation is characterized by the deposition of prodelta sediments. Based on sedimentary lithofacies and facies association, the depositional environment of Laungshe Formation is shallow marine environment.

The Tilin Formation is started the occurrence of coarsening upward delta mouth bar deposits underlain by the very fine grained suspended loads of prodelta deposits of Laungshe Formation. The medium-bedded sandstone intercalated with mud layers also found under the coarsening upward sandstones in the lower part of Tilin Formation. Based on the lithologic characters such as coarsening and thickening upward positions and sedimentary structure of this sediment, the lower part of Tilin Formation is deposition as the upper part subaqueous mouth bar in delta front environment. These delta front sediments are followed by the fining upward sandstones of distributary channel deposits in the lower delta top environments. It showed the regression sea level. Very fine grained sediments, mudstone and shale covered on the fining

upward sandstones in the Tilin Formation. They are suspended loads deposited in delta top environment during flood time (Nichols, 1999). In the middle part of Tilin Formation, prodelta deposits, very fine grained shale are intercalated with fining upward sandstone are represented in the lower part of delta front. These intercalated layers of sandstones are represented the transgression event. These alternation sequences are continued to the upper part of Tilin Formation except the minor occurrence of flood plain deposits, suspended loads. Thus, the depositional environment of Tilin Formation is deltaic environment. Based on sedimentary lithofacies and facies association, the depositional environment of Early Eocene units is deltaic to shallow marine environment.

Conclusions

The research area is a mountainous and forested region and the ranges are running north-south direction. The strata can be classified into two major stratigraphic units such as (1) Laungshe Formation (Early Eocene) and (2) Tilin Formation (Early Eocene). Laungshe formation is mainly composed of thinly laminated dark grey to bluish grey shale intercalated with thin to medium-bedded sandstones. Although Tilin Formation is mainly composed of sandstone, it seems to be subdivided into two members; a lower and upper according to sand/shale (clay) ratio. Early Eocene units are divided into nine lithofacies. The prodelta facies association consists of grey shale facies and mudstone facies in the study area. Thin and horizontal laminated structures are common in the sediments of this association. Very fine- to fine-grained of suspended materials and marine fauna of this lithofacies association indicated prodelta deposit. Delta front facies association mainly consists of thick-bedded sandstone, thin-lenticular bedded sandstone and sandstone intercalated with thinly shale. This lithofacies association includes fine- to medium-grained, thin- to thick-bedded sandstone intercalated with shale. Medium- to thick-bedded sandstones are characterized by thickening upward bedding and coarsening upward grain. Cross bedding is occurred in these sediments. Delta top facies association mainly consists of sand and shale interbedded facies, massive sandstone facies and carbonaceous coaly shale facies. This lithofacies association contains massive sandstone, and alternated layer of thin-bedded sandstones and very thin- to thin-bedded shale. Sand-shale alternation also showed ebb-flood currents with intervening slack-water suspension deposition in delta top environment. Based on sedimentary lithofacies and facies association, the depositional environment of Early Eocene units are deltaic to shallow marine environment.

Acknowledgement

Appreciation is due to Dr. Thin Tun Aung (Rector, Pakokku University) for permission to carry out our research work. We would like to express our gratitude to Dr Khaing Khaing Mon, Professor and Head, Pakokku University, for her permission and departmental facilitates. Finally, we wish to thank to all teachers in Geology Department, Pakokku University, for their help and encouragement throughout this research work.

References

Aung Khin & Kyaw Win, 1969. Geology and hydrocarbon prospects of the Burma Tertiary geosyncline: Union of Burma Jour. Sci. &Teach, v. 2, no.1, p52-73.

Blatt, H., Muddleton, G. and Murry, R., 1980, *Origin of Sedimentary Rock*, 2nd Edition, Prentice-Hall, Inc, Englewood Cliffs, New Jersy, 782pp.

Cotter, G. de P., (1915): *Geology of the country near Ngahlaingdwin, Minbu District, Burma*. *Rec. Geol. Surv. India*. 45, 4.

Graham, J., (1988), Collection and Analysis of Field Data; in *Techniques in Sedimentology*; Tucker, M., Eds, Blackwall Scientific Publications, Oxford, 5-62.

Miall, A. D., (2000), Facies analysis: in *Principles of Sedimentary Basin Analysis*, Springer, Berlin, Germany, 141-248.

Nichols, G. J., (1999), *Sedimentology and Stratigraphy*, 1st edition, Blackwell Scientific Publications, Oxford, 335pp.

Nichols, G. J., (2009), *Sedimentology and Stratigraphy*, 2nd edition, Wiley-Blackwell Scientific Publications, Oxford, 419pp.

Reading, H.G., (1996): *Sediment environment and facies*, Oxford; Black Well. Sic-Publications.

Reineck, H.G. & Singh, I.E., (1980): Depositional sedimentary Environment: Springer, Verlog, N. Y.

Walker, R.G and James, N.P., (1992): *Facies models response to sea level change:* Geological association of Canada, 454 pp.