Abstract

*The Brown Shale in the lower part consists of coal and limestone facies which potentially were deposited in marginal lacustrine area. The limestone was generated by evaporation process characterized by presence of primary calcite crystals.*

*The Brown Shale in the upper part, from bottom to the top is composed of 6 (six) facies associations. Those facies were potentially deposited in shallow to deep water environment of an open lacustrine, characterized by lithology composition, sedimentary structures and fossil contents such as high content reworked organic matters bearing shale and mudstones, density current or turbiditic sedimentary structures and the presence of high content of gastropods and a few bivalves.*

*Keywords: Brown Shale, Pematang Group, Lithofacies, Ombilin Basin*

Introduction

Geologically, the study area is located in Ombilin Basin which is located to the south of Central Sumatra Basin (Figure 1). This basin is a depression producing coal in Sumatra Island. The main objective of this paper is to recognize the lithofacies association, mainly to identify lithology and depositional sequences of Brown Shale based on recent fieldwork in Karbindo Coal Mine which is probably equivalent to Pematang Formation as defined by previous investigators.

Pematang Formation was informally divided into lithology units consisting of Lower Red Beds in the lower part, Brown Shale in the middle part and Upper Red Beds in the upper part. According to Caughey et.al (1994) in De Smet M.E.M & Barber A.J., (2005), the Lower Red Bed unit is composed of sandstone, shale and conglomerate, deposited in alluvial and fluviatile system environments. The Brown Shale mainly consists of dark brown to black shales deposited in lacustrine environment and the Upper Red Bed is composed of fine to coarse sandstone,
siltstone and claystone deposited in a fluviatile environment. The Brown Shale is well exposed in the Karbindo Coal Mine area as an overburden rock formation overlying coal seam; it provides the valuable information to support exploration activities regarding as a source rock for hydrocarbon in Central Sumatra Basin.

Figure 1. Location of Ombilin Basin (red circle), West Sumatra (After Barber, 2005)

**Methodology**

The study area is situated to the east of Padang, West Sumatra. This area administratively belongs to Kemang Baru District in Region of Sijunjung, has been regionally mapped by Silitonga P.H & Kastowo (1995) of Geological Research and Development Centre, which published 1:250,000 Geological Map of Solok Sheet. This area also has been studied by Koesoemadinata and Matasak in 1981 which published a paper discussing of stratigraphy and sedimentation of Ombilin Basin.

The used base map is Topographic Map of Sungai Lansat sheet scale 1:50,000, from Bakosurtanal, Indonesia. The lithological successions exposed at sections of Karbindo Coal Mine area occupied by lithology constituent of Brown Shale unit of the Pematang Formation (Figure 2) and its surroundings. The fieldwork was conducted to identify lithological type and any general/special characteristics (mineral composition, grain size, weathering, diagnostic sedimentary structure, and fossils content), lateral and vertical stratigraphic distribution. Petrographic studies on lithologic samples are for the purposes of mineralogy composition, rocks texture and structure determining as well as environmental interpretation.
Result and Discussion

Lithofacies association succession developed in the observed Brown Shale unit from lower to upper part shows a repetition of sedimentation cycle and can be divided into facies association (Figure 2) as follow:

A. Coal and limestone facies
B. Amalgamated massive-thick bedded shale facies
C. Interlaminated shale and siltstone facies
D. Interbedded grey and red shale facies
E. Fossiliferous shale facies.
F. Massive-thick beds shale facies
G. Interlaminated shale and sandstone facies

A. Coal and Limestone Facies

Coal and limestone facies (Figure 3), it comprises several coal beds tends to show thinning upward. The coal beds are black, vitreous, concoidal fractured and jointed with vertical and horizontal cleat, occasionally filled by calcite veins. The coal beds are occasionally intercalated by limestone or interbedded with limestone.

Limestone also consists of several beds which are intercalation in coal and or interbedding with coal. In general the limestone are light brown, hard, very
fine grained or micritic; often contain lot of carbonaceous matter and thin layers or laminations of coals. The thickness of limestone beds range from 3 cm to 1 m. Microscopically, the limestone is mainly supported by calcite crystalline and contains organic matters laminae.

![Figure 3. Interbedded coals and limestone showing repetition of thickening and coarsening upward cycles, a few limestone wedges out into coal seam](image)

Very difficult to determine the age of rocks because there are no fossil index for age determination, however, the presence of (?) *Florschuetzia trilobata* suggests that the age of the sample probably range from Eocene to Midle Miocene.

On the basis of lithology composition and their sedimentary structures suggest that the coal facies was deposited in fresh water swampy or marsh environment occupied by bog forest during wet season or in high water. This is supported by presence of brackish water polen of *Dicolpopollis* sp. The limestone facies was deposited in stagnant water in pool or depression and or swampy environment underwent evaporation during long period dry season or airy condition producing evaporation minerals such as calcium carbonate (calcite) and siderite (iron carbonate);

On the basis of those data suggest that depositional environment of the coal and limestone were in environments developed in fresh water depression or lacustrine.
B. Amalgamated massive-thick bedded shale facies

Massive Facies (Figure 4) is characterized by interbedded - amalgamated aggradational thick, massive (structureless or very rare) beds of shale. The shale is dark brown, calcareous and carbonaceous and contains sandy and silty matters, occasionally forming discontinuous and continuous parallel laminations. The thickness of this facies is about 6.5 meters.

This amalgamated shale facies was potentially deposited in low energy and deeper water environment compared with this of coal and limestone deposition. It was probably deposited during long period wet season causing shoreline of lake moves landward and suspended influx sediments filled the basin. Due to the sequence of beds show aggradation stacking pattern suggest that during their deposition the rate of subsidence is equivalent to this of rate influx sediments. The contact with the underlying limestone could be assumed as a flooding service.

![Figure 4. Thick bedded calcareous and carbonaceous silty-sandy dark brown shales of massive Shale Facies association](image)

C. Interlaminated Shale and Siltstone Facies Association
Interlaminated Shale and Siltstone Facies Association (Figure 5) is almost contains tight laminations (<1cm) formed by sandy, silty, muddy calcareous, carbonaceous and iron matters. Microscopically shows wavy laminations of calcite, mud or clay, iron oxide and carbonaceous matters. On measured section, the thickness of this facies is about 10 meters.

This interlaminated shale and siltstone facies was potentially deposited in a shallow water lake with low oxygen and low acidic condition indicated by presence of siderite (FeCaO$_3$) and also tight wavy - current ripple lamination structures. The presence of tight wavy -ripple sedimentary structures indicate that structures formation was influenced by wave activity blown by wind, so the base of water should be a shallow water environment.

The presence of calcite, kaolin and quartz minerals in the rock suggest those minerals were probably transported from fluvial and marginal lake sediments.

![Figure 5. Well bedded interlaminated of shales, sandy.silty, muddy calcareous, carbonaceous and iron matters](image)

**D. Interbedded Dark Grey Shale and Red Mudstone Facies**

Interbedded Dark Grey Shale and Red Mudstone Facies (Figure 6) is almost similar to the underlying interlaminated shales and sandstone facies, differ from underlying facies is on sedimentary structures developed are more little and
rare. This facies is mainly composed of interbedded-amalgamated massive thick bedded shale and mudstone, intercalated by sandstone, siltstone and claystone. Shale is dark brown, dark grey to black, carbonaceous and calcareous and contains rich organic matters. Mudstone is reddish brown, calcareous, 5 - 15 cm thick. Sandstones are calcareous grey - greenish grey, fine - very fine grained, calcareous and often show very thin graded bedding structures. Siltstone is grey and commonly as laminated. Claystone is white, thin to very thin form as part of sedimentary structures.

The sedimentary structures developed in this facies are commonly in small scale comprising graded bedding, parallel lamination, current ripple lamination and slump structures, which are probably as turbidity structures. The thickness of this massive thick shales and silstone is about 29.5 meter. Potentially was accumulated in deep water characterized by presence of sedimentary structures consisting of graded bedding, load cast, current ripple and slump laminations, whereas the thick beds of shale were deposited in suspended ways in low energy condition.

The fossiliferous shale facies (Figure 7) overlies the massive shale facies with gradual contact. This facies consists of interbedded dark brown - black shale and red shale containing rich angular fragments (1-2 cm) of gastropods and minor bivalve mollusk (up to 4 cm in diameters). Those fossils are commonly concentrated in the bottom of layer and more scattered in the upper part of beds occasionally form graded bedding structures like. The thickness of the fossiliferous
fossils on the section is 13.5 meters. Potentially was deposited in deep water environment characterized by presence of gastropods fragments, which were probably transported by density current from beach or shallower environment. Although the environment was in deep water, but this facies was accumulated more proximal than the dark grey shale and red mudstone facies.

F. Massive–thick bed shale Facies

Massive-thick bed shale facies (Figure 8) is conformably overlies the fossiliferous shale facies. Consists of homogeneous, amalgamated massive-thick bedded shale, mudstones intercalated by white clay and red mudstone. The shale and mudstones are dark brown to black, calcareous and carbonaceous, commonly contain rich organic content, thick to very thick (30 cm – 1.5 m), commonly massive or structure less but occasionally contain parallel laminations sedimentary structures formed by carbonate grains. Petrographically, several shale show good parting or fissility features. The claystone is white, 20 cm - <1cm thick. Contain parallel and slump lamination structures. The thickness of this facies in the section is about 60.5 meter. Potentially was accumulated in deep water characterized by presence of graded bedding, parallel and slump lamination sedimentary structures which are usually formed by density current. The environment is more distal than
this of fossiliferous shale facies. The calcite, quartz and kaolin were transported away from the land.

Figure 8. Massive shale facies containing rich organic content, with interbedded shale and calcareous sandy and iron laminations showing graded bedding

G. Interlaminated-thin bedded Shale and Siltstone Facies

Interlaminated-thin bedded Shale and Siltstone Facies (Figure 9) is a uppermost facies in the section, consists of interlaminated-very thin bed of mudstone, shale, sandstone and siltstone Those rocks are composed of, shally, sandy, silty, muddy calcareous and carbonaceous matters. Petrographically those rocks predominantly consist of mudstoes and shale which respectively do not show fissility parting. Sandstones is fine grained composed of grains of feldspar, carbonate, organic matters and clay matrix indicating the rocks are feldspathic wacke. The lithologic characteristics of the facies contains tight or very closed laminated forming repetition of parallel, wavy-ripple, slump and graded bedding sedimentary structures. The thickness of this facies is about 81.50 meter on section. Potentially deposited in deep water but more proximal than Massive-thick bed shale facies, which are characterized by presence of sedimentary structures such as graded bedding, load cast, parallel, ripple-wavy and slump laminations, usually formed by density current or turbidity current. The constituent of the rocks were probably derived or reworked from land or shallower environments.
Figure 9. Interbedded fine to very fine sandstones sandstone and mudstone showing repetition of graded, bedding, parallel and ripple laminations composed of carbonate and iron matters. Load cast and parallel lamination formed by calcareous, carbonaceous sandy, silty, muddy matters.

Conclusion

Recent fieldwork points out that the Tertiary lithostratigraphy units exposed in the Karbindo Coal Mine and surrounding areas probably equivalent to Pematang Formation as defined by previous investigators. Two lithology units of Pematang Formation are exposed, namely the Lower Red Bed and Brown Shale.

Lithofacies association developed in the Brown Shale unit from lower to upper part shows a repetition of sedimentation cycle and can be divided into facies association as follow:

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