

# Characterization Of Coal Quality Based On Ash Content From M2 Coal-Seam Group, Muara Enim Formation, South Sumatra Basin

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## Abstract

Muara Enim Formation is well known as coal-bearing formation in South Sumatra Basin. As coal-bearing formation, this formation was subjects of many integrated study. Muara Enim Formation can be divided into four coal-seam group, M1, M2, M3, and M4. The M2 group comprising of Petai (C), Suban (B), Lower Mangus (A2), and Upper Mangus (A1). Depositional environments of Group M2 is transitional lower delta plain with sub-depositional are crevasse splay and distributary channel. The differentiation of both sub-depositional environments can be caused the quality of coal deposit. One of quality aspects is ash content. This research conducted hopefully can give better understanding of relationship between depositional environments to ash content. Group M2 on research area were found only Seam C, Seam B, and Seam A2, that has distribution from north to central so long as 1400 m. Coal-seam thickness C ranged between 3.25-9.25 m, Seam B range 7.54-13.43 m, and Seam C range 1.53-8.37 m, where all of coal-seams thickening on the central part and thinning-splitting to northern part and southern part. The ash content is formed from burning coal residue material. Ash contents on coal seam caused by organic and inorganic compound which resulted from mixing modified material on surrounded when transportation, sedimentation, and coalification process. There are 27 sample, consists of 9 sample from Seam C, 8 sample from Seam B, and 10 sample from Seam A2. Space grid of sampling is 100-150 m. Ash content influenced by many factors, but in research area, main factor is existence of inorganic parting. Average ash content of Seam C is 6,04%, Seam B is 5,05%, and Seam A2 is 3,8%. Low ash content influenced by settle environment with minor detrital material. High ash content caused by oxidation and erosional process when coalification process. Ash content on coal in research area originated from detritus material carried by channel system into brackish area or originated from higher plant in brackish area. The high ash content also can be caused by after the coal deposited. It had originated from overburden horizon which infill in cleat of coal seam.

**Keywords:** Muara Enim Formation, Group M2, Transitional Lower Delta Plain, Ash Content.

## 1. Introduction

### 1.1. Background

Muara Enim Formation is well known as coal-bearing formation in South Sumatra basin. As coal-bearing formation, this formation was subjects of many integrated study, such as sedimentology, depositional environment, paleogeography, structure geology, tectonic evolution, depositional history, and many more (De Coster, 1974).

Muara Enim Formation consists of sandstone, claystone and coal. Coal in bottom part of Middle Palembang formation in southern part of this basin often used as stratigraphy marker. Muara Enim formation can be divided into four coal-seam group, M1, M2, M3, and M4. (De Coster, 1974) interpreted this formation deposited in Late Miocene-Pliocene.

The M2 group is comprising of Petai (C), Suban (B), Lower Manggus (A2), and Upper Manggus (A1). Group M2 consists of intercalated of claystone-sandy claystone, fine-medium sand, coal in bottom part. Coal seams in Group M2 have limited distribution. It caused by depositional environment from this unit. Depositional environment of Group M2 is transitional lower delta plain with sub-depositional are crevasse splay and distributary channel.

The differentiation of both sub-depositional environments can be caused the quality of coal deposit. One of quality aspects is ash content. This research conducted hopefully can give better understanding of relationship between depositional environments to ash content.



deposited on transgression phase are Telisa Group (Talang Akar Fm., Baturaja Fm., and Gumai Fm.). On other side, regression phase deposited Palembang Group (Air Benakat Fm., Muara Enim Fm., and Kasai Fm.). Older formations (Lemat Fm. and Older Lemat Fm. deposited before main transgression phase. Stratigraphy unit of South Sumatra Basin from oldest to youngest (De Coster, 1974), are Pre-Tertiary Group, Kikim Fm., Older Lemat Fm., Lemat Muda Fm., Talang Akar Fm., Baturaja Fm., Telisa Fm., Gumai Fm., Lower Palembang Fm., Middle Palembang Fm., and Upper Palembang Fm. (Fig. 4).

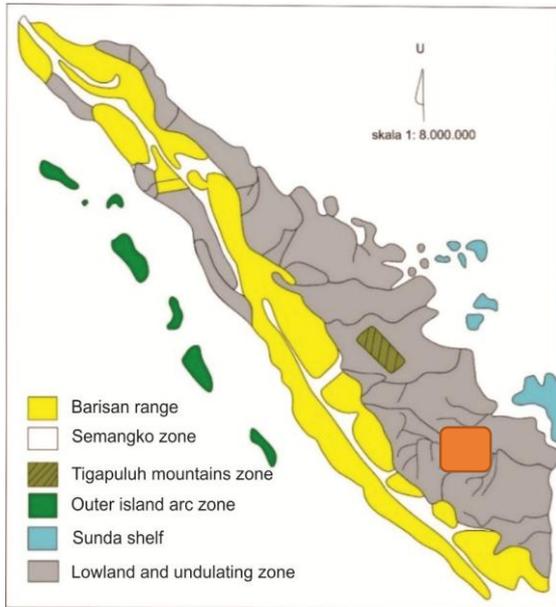


Fig. 3. Physiography zone of Sumatra (Bemmelen, 1949).

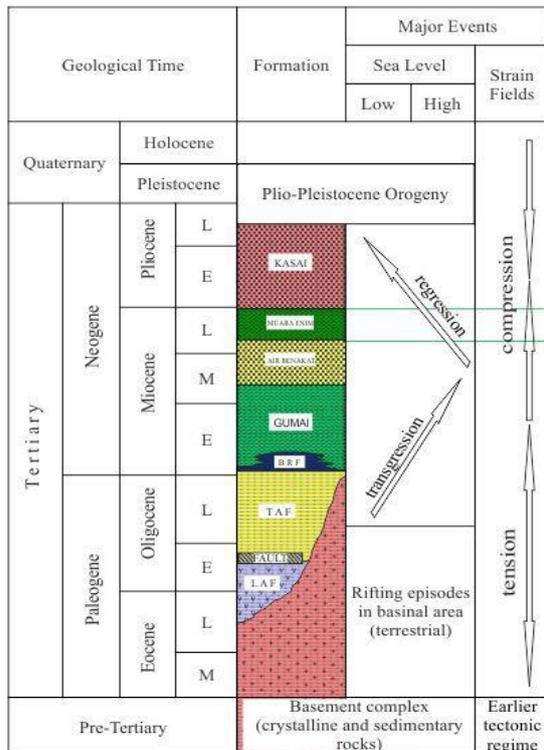


Fig. 4. Regional stratigraphy of South Sumatra Basin (Sutriyono et al., 2016).

Muara Enim Formation is coal-bearing formation in South Sumatra Basin. Muara Enim Formation can divided into four coal-seam group (Ilyas, 1999), accordingly from bottom to top are M1, M2, M3, and M4 (Fig. 5). The M2 group have found in research area. Group M2 contains majority of coal resources in Tanjung Enim area. The M2 consists of three major coal unit (from top to bottom); Mangus, Suban and Petai (Amier, 1991). Recognized these unit locally split into two seams as follows: Mangus unit (A1 and A2 seams), Suban unit (B1 and B2 seams), and Petai unit (C1 and C2 seams)

Coal Bearing Formation	Coal Seam Unit	General Description	Coal Seam
MUARA ENIM	M4	Blue green tuffaceous clays and sandy clays, some dark brown coaly clays. Some white and grey, fine to coarse sands, at times slightly glauconitic. Single pumice stone layers in the central Palembang area (120-200m thick)	Niru Lematang Babat/ Benakat Kebon
	M3	Sand and silt complex. Underlain by predominantly blue-green grey green and grey brown clay complex. Few thin calcareous and domitic bands. Sand horizon of 3-6m, about 40m above Mangus with some gas pocket (100-280m thick)	Benuang Burung Mangus
	M2	Brown to grey clays and sandy clays brown, grey, fine to medium sands, some green, grey fine grained sands in lower part (40-120m thick).	Suban Petai
	M1	Brown and grey sands, silts and clays, with minor glauconitic sands (120-250m thick).	Merapi Keladi

Fig. 5. Stratigraphy of Muara Enim Formation (modified (A.D.Tarsis, n.d.)).

Pulunggono, 1986 interpreted Muara Enim formation deposited in shallow marine to paralic and non-marine environments. This formation consists of claystones and shales intercalated by sandstone and coal layer.

On other hand, based on analysis of well and seismic data, divided Muara Enim formation into two depositional packages: Lower and Upper Muara Enim formation (Muksin et al., 2012). These two depositional packages consists of three sub-environment, they are tidal mud flat, tidal mixed flat and tidal sand flat environment.

### 3. Research Method

Research method was conducted on this study are:

- Field observation, including observation of relationship coal layer to other layers (bottom and top) and also the condition which influenced the layers.
- Quality analysis of coal layer to identified distribution of coal layer and geology factors.
- Research were conducted by reconnaissance through study literature and field observation, analyses phase (primary analysis and secondary analysis), and conclusion phase (result).

Group M2 on research area were found only Seam C, Seam B, and Seam A2, that has distribution from north to central so long as 1400 m (Fig. 6).

Coal-seam thickness C ranged between 3.25-9.25 m, Seam B range 7.54-13.43 m, and Seam C range 1.53-8.37 m, where all of coal-seams thickening on the central part and thinning-splitting to northern part and southern part.

The ash content is formed from burning coal residue material. Ash contents on coal seam caused by organic and inorganic compound which resulted from mixing modified material on surrounded when transportation, sedimentation, and coalification process. There are 27 sample, consists of 9 sample from Seam C (Table 1), 8 sample from Seam B (Table 2), and 10 sample from Seam A2 (Table 3). Space grid of sampling is 100-150 m. The coal quality analysis discussed throughout this research were analyzed on air dried basis (adb.).

Table 1. Ash value of seam C.

Sample Code	Seam	Ash Value (adb)
FR-11	C	4,66
FR-15	C	8,13
FR-12	C	6
FR-16	C	7,45
FR-17	C	7
FR-10	C	4,73
FR-05	C	5,59
FR-14	C	7,24
FR-07	C	2,23

Tabel 2. Ash Value of Seam B.

Sample Code	Seam	Ash Value (adb)
FR-01	B	5,63
FR-08	B	8,04
FR-02	B	5,61
FR-12	B	6,4
FR-10	B	3,07
FR-05	B	4,95
FR-14	B	3,69
FR-07	B	3,05

Table 3. Ash Value of Seam A2.

Sample Code	Seam	Ash Value (adb)
FR-01	A2	3,03
FR-08	A2	1,71
FR-02	A2	2,48
FR-03	A2	3,39
FR-09	A2	2,59
FR-04	A2	3,28
FR-10	A2	3,24
FR-05	A2	2,71
FR-07	A2	6,85
FR-06	A2	9,56

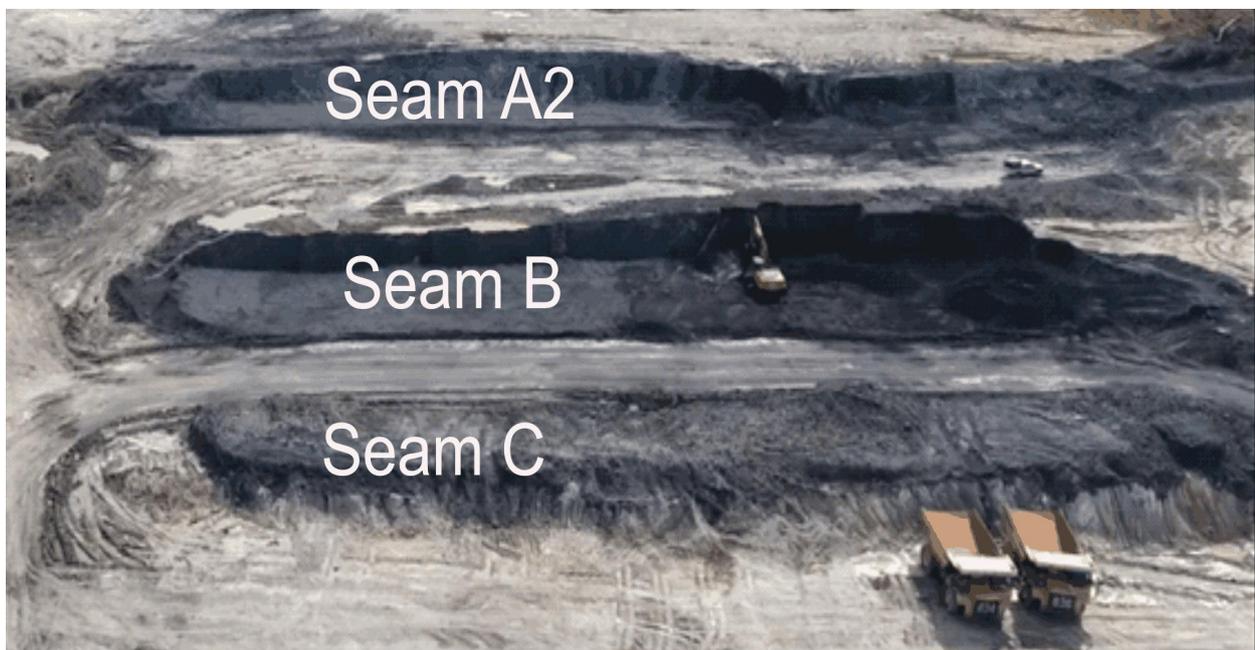


Fig. 6. Outcrops of seam A2, seam B, and seam C.

#### 4. Result and Discussion

The ash contents for all samples varies slightly, with average ranging from 1.71-9.56 adb.%.

##### 4.1. Ash content analysis of Seam C

Seam C on research area have thickness around 3.25-9.25 m, where divided into 5 body with 4 parting with various thickness between 5-30 cm. Stratigraphic profile of Seam C can be seen on Fig. 7.

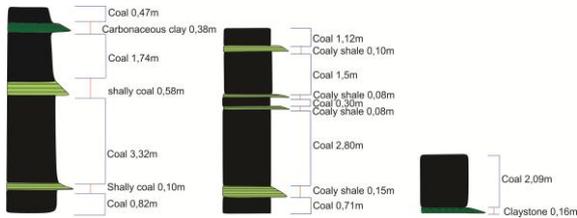


Fig. 7. Coal profile of coal-seam C in northern (left), central (middle), and southern (right) of research area.

Based on ash content on Seam C (Fig. 8), showed highest ash content located on central part of research area, besides that northern and southern part have low ash content. It can be caused by northern and southern part are depocenter of basinal area. This condition made coal layer on this part have thick layer and less of parting. The highest ash content located on central part of research area, it indicated that coal deposited in edge of basinal area. This part could influenced by terrestrial material. This condition indicated why ash content on edge of basinal have ash content higher than depocenter of basinal area.

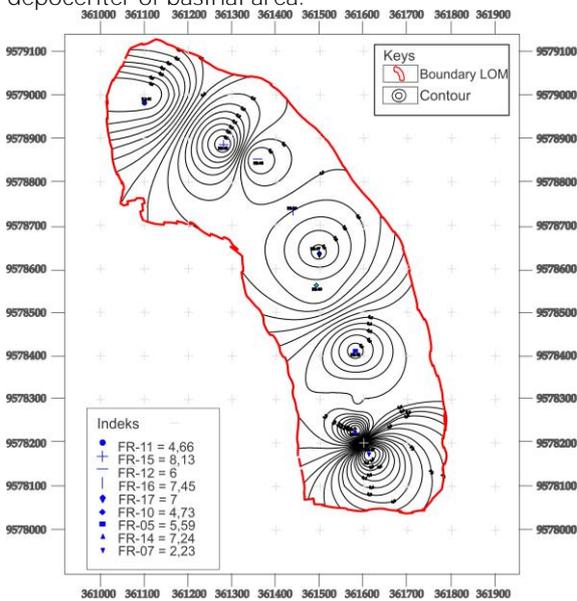


Fig. 8. Iso ash map of Seam C.

##### 4.2. Ash content analysis of Seam B

Seam B on research area have thickness around 7.54-13.43 m, where divided into 5 body with 4 parting with various thickness between 4-20 cm. Stratigraphic profile of Seam C can be seen on Fig. 9.



Fig. 9. Coal profile of coal-seam B in northern (left), central (middle), and southern (right) of research area.

Based on ash content on seam B (Fig. 10), showed ash content increased to northern part. That analysis indicated that coal seam B in northern part deposited in edge of basinal area. This part could influenced by terrestrial material. This condition indicated why ash content on edge of basinal have ash content higher than depocenter of basinal area.

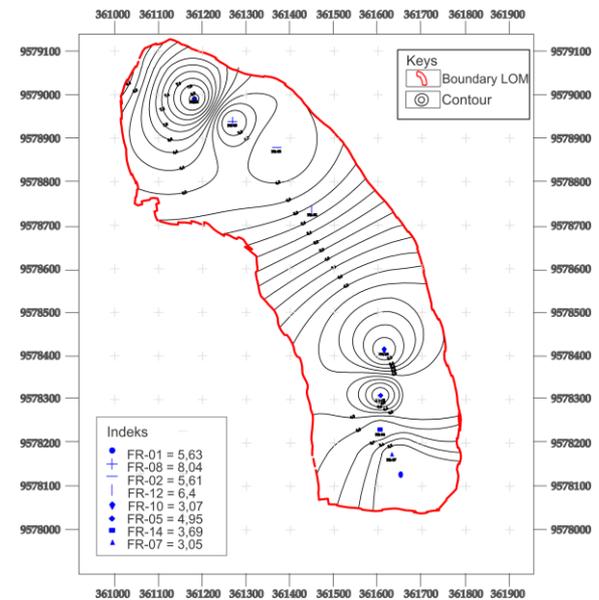


Fig. 10. Iso ash map of Seam B.

##### 4.3. Ash content analysis of Seam A2

Seam A2 on research area have thickness around 1.53-8.37 m, where divided into 3 body with 2 parting with various thickness between 5-10 cm. Stratigraphic profile of Seam C can be seen on Fig. 11.

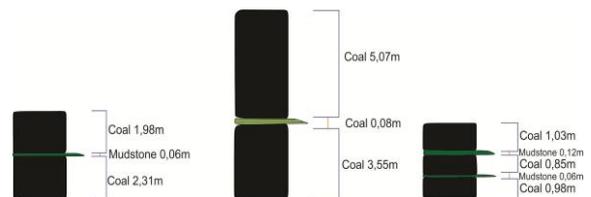


Fig. 11. Coal profile of coal-seam A2 in northern (left), central (middle), and southern (right) of research area.

Based on ash content of seam A2 (Fig. 12), showed ash content increased to southern part. It caused by southern part is edge of basinal area. Coal which deposited in edge of basinal area mainly influenced with terrestrial material. It resulted coal in this area have higher ash content than central part. The low ash content in central part was assumed that minor terrestrial content. It indicated the area is depocenter of basinal area.

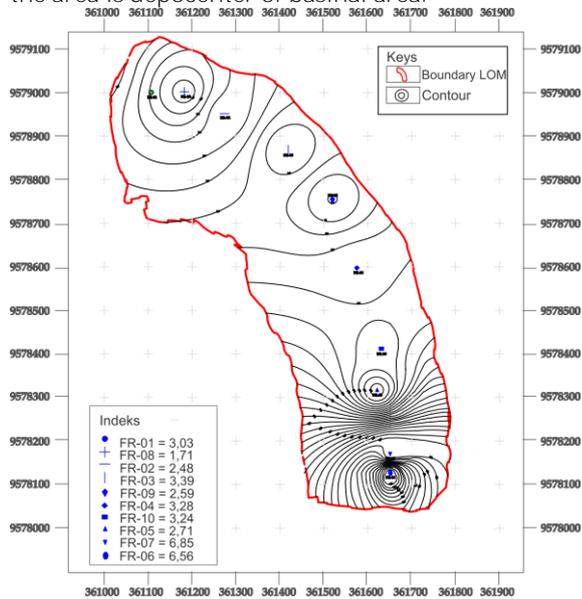


Fig 12. Iso ash map of Seam A2.

#### 4.4. Interpretation of depositional environment

Depositional environment of Group M2 in research area is transitional lower delta plain by using [horne, 1978](#) classification of depositional environment based on coal characteristic. It indicated by lithology changed and repeated lithology as characteristics of depositional processes influenced by tidal ([Thomas, 2013](#)) (Fig. 13).

Parting occurrence on coal seam in research area caused by in depositional processes of coal there are flooding phase or formed by tidal process which caused fine grain sediment also deposited coincided with coalification process. But fine grain sediment was not continuous deposited because the limited source of this material. The depositional process

still occupied to deposit peat material and coalification process. This process can be caused occurrence of parting in coal seam.

Ash content on coal seam in research area originated from detritus material which brought by channel system into brackish area or originated from higher plant in brackish area. The high ash content also can be caused by after the coal deposited. It can origin from overburden horizon which infill in cleat of coal layer.

In research area, coal seam have found with various thickness (thick and thin). It influenced by two processes: process when depositional takes place and process after deposited. First process is basin subsidence, if there are rapid subsidence it could made thick coal seam. Second process is erosional process by channel changing. It could be caused thinning on edge of coal seam. On other hand, various coal thickness can also influence by different of rate of peat growth. If rapid peat growth rate, it caused thick coal layer, but if slow peat growth rate, it caused thin coal seam.

#### 5. Conclusion

Coal-seam group of Muara Enim Formation in research area occurred on Group M2 unit which consists of Seam C, Seam B, and Seam A2. Group M2 have various thickness. Thickness of Seam A2 is around 1.53-8.37 m. Seam B between 7.54-13.43 m, and Seam C have thickness is 3.25-9.25 m. All of seam have thickening geometry in central part and thinning in both of edge part (northern and southern part).

Based on sedimentation characteristic, Group M2 in research area deposited in transitional lower delta plain with sequence interburden characteristics, intercalated of fine-coarse grain with fining upwards and coarsening upwards, thick coal seam with continuous distribution.

Ash content influenced by many factors, but in research area, main factor is existence of parting. Average ash content of Seam C is 6.04 adb.%, Seam B is 5.05 adb.%, and seam A2 is 3.8 adb.%. Low ash content influenced by settle environment with minor detrital material. High ash content caused by oxidation and erosional process coincided with coalification process.

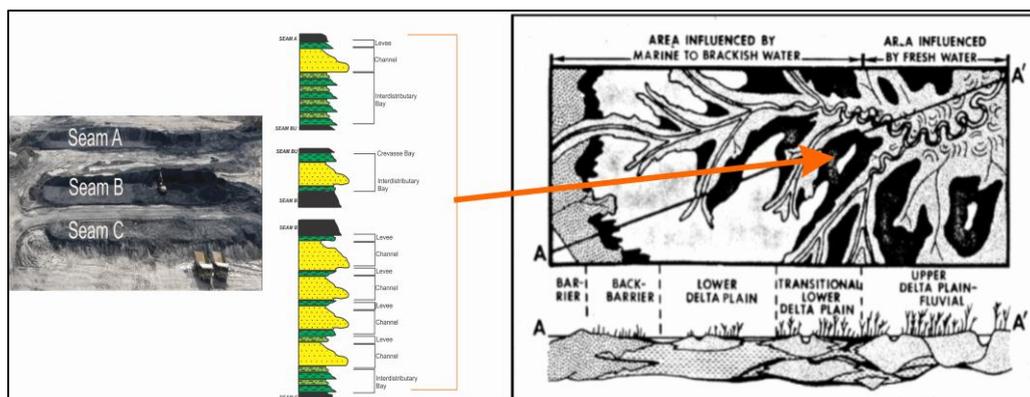


Fig. 13. Measuring section model compared to depositional environment of Group M2.

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