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Macerals Analysis *Seam* M2 Muaraenim Formation, : Implication toward Coal Facies and Coal Rank In Kendi Hill, South Sumatra

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Abstract

The Muaraenim Formation is a coal bearing formation in South Sumatra Basin of the Late Miocene – Pliocene. Muaraenim Formation based on coal seam content is divided into four seam, are: M1, M2, M3 and M4. Coal seam in this area include in seam M2 member, with the general characteristics of the presence of silicified coal on the roof and floor of coal seams as a marker. The administration of the research area is located in east Kendi Hill, South Sumatra. The Kendi Hill is composed of adesite igneous rocks that intruded Muaraenim Formation in unconformity at the time of Pleistocene. This study aims to determine the environment of coal depositional based on maceral analysis and determine the factors influence the physical characteristics of coal seams in Kendi Hill. Data that has been obtained from the field, then conducted a selection process.The number of samples analyzed were nine sample based on near and far to the Kendi Hill spread from the southern, central, and northern of the location. The result of the analysis will display the maceral diagram. Megascopically, coal seam in the Kendi Hill are black, dull with bright, uneven – subchoncoidal, blackish brown in streak, have a pyrite and resin. The thickness of the coal seams ranges from 0,45 to 14 meters. Based on the maceral analysis, the coal seam in the Muaraenim Formation is composed dominated by vitrinite, then liptinite, inertinite and mineral matter pyrite (1,6-6,6%). Vitrinite reflectance of coal in the research area ranges from (0,37-0,48%) that included to the Sub-bituminous – High Volatile Bituminous C. From the results of Tissue Preservation Index and Gelification Index value indicated that the coal facies in the research area was a limnic to wet forest swamp. Whereas the deposition of the Muaraenim Formation in deltaic environment (Transitional lower delta plain).

Keywords: Coal, Maceral, Muaraenim Formation, South Sumatra Basin

1. Introduction

Indonesia is a country that has a lot of natural resources, one of which is a natural wealth in the field of energy is coal. In the current state of coal in Indonesia has a variety of physical characteristics of formation. According to Horne (1978) the sedimentary environment affects the distribution, thickness, and severity of coal. Based on characteristics of coal deposition environment, it divided into four (4); Barrier and Back-barrier, Lower Delta Plain, Transitional Lower Delta Plain, and Upper Delta Plain. Furthermore, according to Diessel (1986) and Diessel (1992) the presence of the smallest element in coal is very important to be a specific environment and discussed maceral content, coal rank, coal facies on chemical and biology based on Tissue Preservation Index (TPI) and Gelification Index (GI). The role of the maceral is based on the properties they possess, including the nature of the attribute and scalar nature. Furthermore used the Ward (1986) classification to know coal rank of the research area based on the vitrinite reflectance value (Rv) obtained from the laboratory test. The environment of coal depositional based on Horne (1978) and coal facies determination theory Diessel (1986) still used by Pratama and Amijaya (2015) as reference for determining the depositional environment and coal facies based on organic petrographic analysis.

This research aims to determine the environment of coal depositional based on maceral analysis, determine the coal facies and coal rank in Kendi Hill and determine the factors influence physical characteristics of coal seams in the research area.

The administration of the research area is located in east Kendi Hill, Pulau Panggung Village, Muaraenim Regency, South Sumatra (Fig. 1). Access to the research area can be reached from the city of Palembang through the land route cross Sumatra + 200 km to Tanjung Enim district, and continued through the village path of the Pulau Panggung by using a four-wheeled. Spatial area of research is located in Sub Basin of South Palembang, whereas stratigraphy is in Muaraenim Formation (Tmpm), Kasai Formation (Qtk), and Andesite Intrusion (Qpva).

2. Geological Setting

The location of the research area is in the Muaraenim Formation and units of young volcano (andesite intrusion).

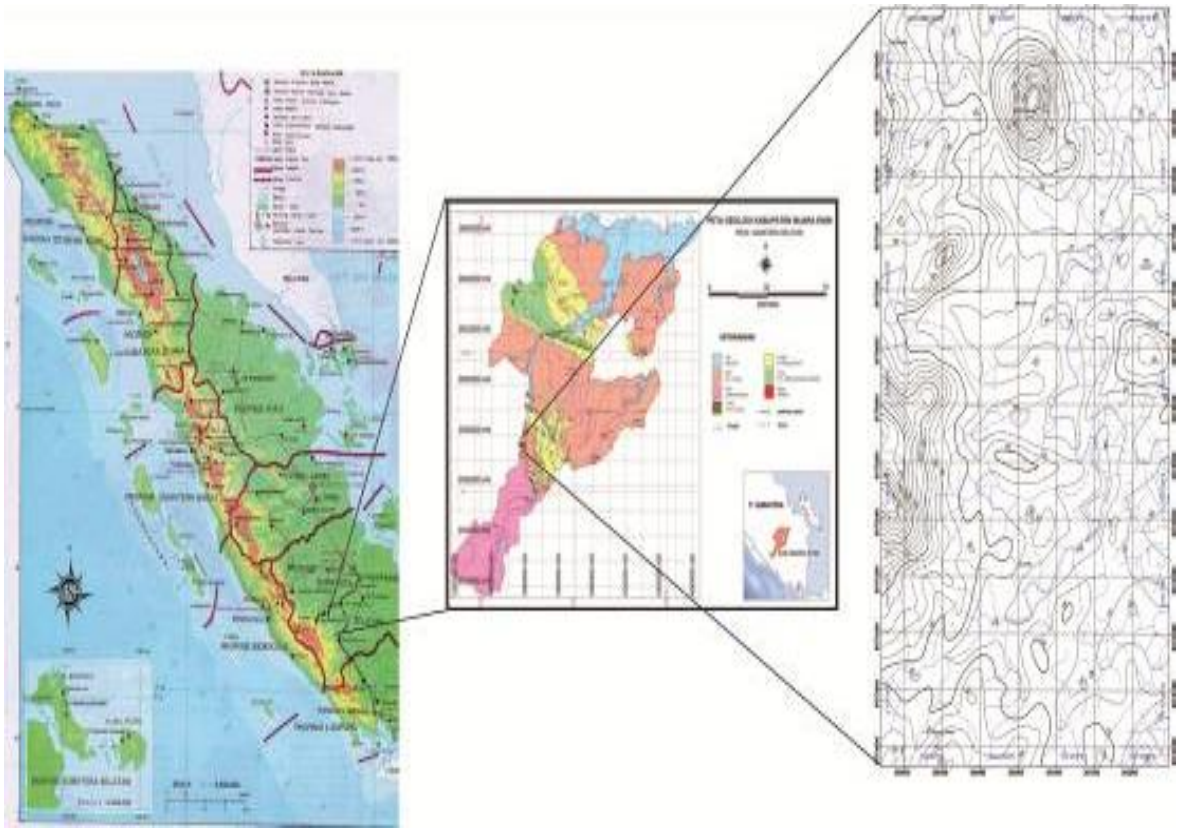

Fig. 1. Location map of research area.

The Muaraenim Formation conformably overlaying with Airbenakat Formation that composed of sandstone, sandy claystone, tuffaceous sandstone and mudstone with coal intercalation (Heryanto, 2006). Muaraenim Formation is a coal bearing formation in South Sumatra Basin of the Late Miocene – Pliocene. According to Shell (1978), in ideal condition Muaraenim Formation is divided into several members, namely M1, M2, M3, and M4 (Fig. 2). Member of M2 consists of clay, carbonaceous clay, siltstone, claystone, and coal. M2 member have three main layers; seam C (petai seam), seam B (suban seam), and seam A2 (Mangus seam). Petai seam is the lower limit on seam M2 which has the characteristics of the availability of silicified coal on the floor. Suban seam between the petai seam and mangus seam, which has a thick enough silicified coal on the floor. Mangus seam is the upper limit on seam M2 which has the characteristics of the availability of silicified coal on the top seam.

The unit of the young volcano (Kendi Hill) is one of the intrusions of igneous rocks located in the research area of Pleistocene. The intrusion is formed on the surface because of the flow of magma derived from shallow dome that causes uplift, fault, and fold (Fig. 3) (Amijaya and Littke, 2006).

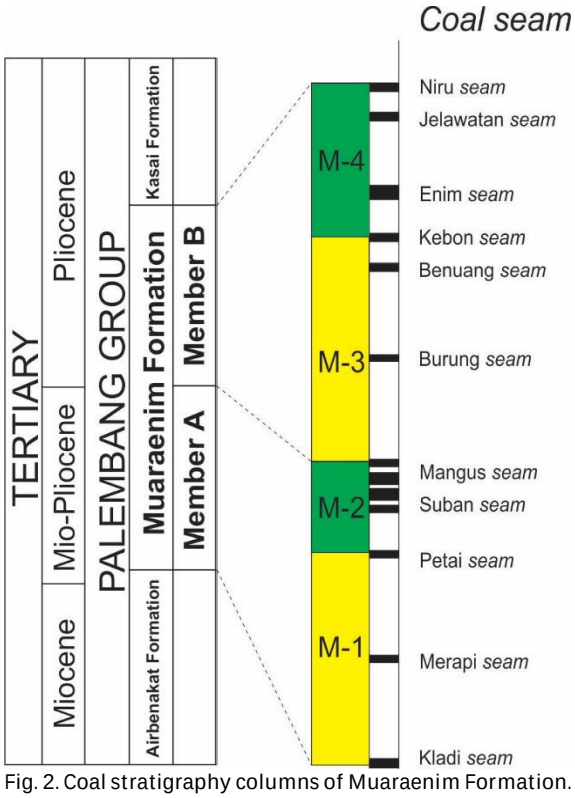

Fig. 2. Coal stratigraphy columns of Muaraenim Formation. Seam M2 (Modified from Shell, 1978).

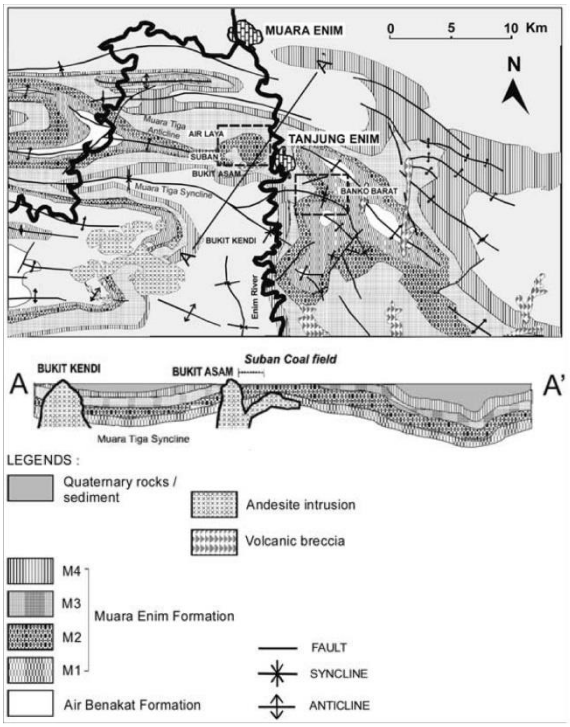

Fig. 3. Geological map and geological section of the Muaraenim area (Modified from Bamco, 1983; Gafoer et all., 1986 on Amijaya and Little 2006).

3. Methods

The research used descriptive-observative methods, used consisted of literature study, field observation in the from of measured section to know geometry, lithology, sediment structure and physical description coal seam. The method used in sampling is channel sampling, taking representative of coal seam from floor to roof then mixed into one plastic sample.

The analyzed coal samples were nine (9) samples with coal deployment analyzed each located in the northern part of research area amounting three samples, in the center of research area were three samples, and in the southern of research area were three samples representing each coal seam. The sample of coal taken is distinguished by near and far from Kendi Hill. Samples located near Kendi Hill are north coal samples and those far from Kendi Hill are southern coal samples.

The method of maceral analysis on coal, tool used is point counter to identify and calculate the number of macerals, then ray reflection microscope function to know the type of maceral and mineral present in coal with the number of observations on each sample as much as 500x. As for measuring the reflectance value of the vitrinite maceral group to determine the rank of the coal, the measurements were carried out under an immersion oil medium. Based on the results of the analysis, the depositional environment, coal facies, and coal rank of the research area can be determined by the consisting of maceral content and vitrinite reflectance.

4. Result and Discussion

4.1 Depositional Environment Seam M2, Muaraenim Formation in Kendi Hill

Based on environment analysis of coal deposition, Muaraenim Formation is included into the Transitional Lower Delta Plain (Fig. 4). According to this model, the Transitional Lower Delta Plain depositional environment is composed of repetition lithology (from bottom to top) from roof seam C (petai) to floor seam A2 (Mangus) is coal, claystone, sandstone layer, siltstone, sandstone, claystone, and coal seam.

Lithology on research area consisting of claystone, siltstone, and sandstone with parallel laminae carbonaceous, indicated sedimentary coal bearing on seam M2 found vertically in the transition environment of Upper Delta Plain to Lower Delta Plain with some layers showing tidal deposits associated with fine-grained material deposits. Sub-deposition environment found is crevasse spays, swamp, and interdistributary channel.

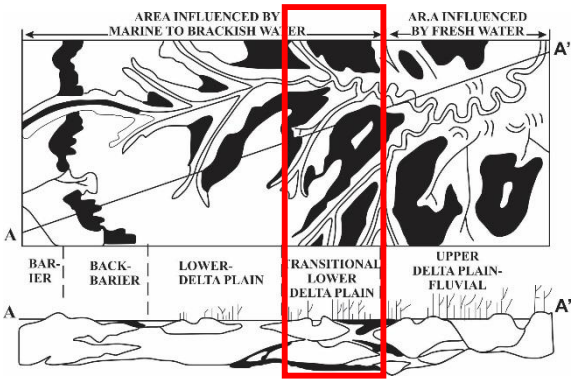

Fig. 4. Coal depositional environment on Seam M2 based on Horne (1978).

Crevasse spays are deposits of flooded outflows associated with swamp environment that erode levee and chop, allowing the water to overflow into the floodplain on the left and right sides of the river to formed crevasse splays deposit. Characteristics of sediment found in the area of fine grains with parallel laminae carbonaceous structure composed by fine sandstone and siltstone with thick enough. Swamp is a environment containing coal-forming plants with lithology mudstone and claystone filling in the fracture of coal during deposition process. Interdistributary channel is an environment is formed with weak energy and calm conditions, that in this zone will be deposited lithology material siltstone and claystone dominant. This area sub-environment acts as interburden between coal seam (Fig. 5).

The encounter of impurities in the coal seam is resin and pyrite, indicated the coal in this area composed by organic materials derived from large trees. Thus the environment of coal deposition is the terrestrial. While the presence of mineral matter pyrite in coal indicated the influence of other marine environment. (Fig. 6).

Based on maceral analysis conducted on nine samples of coal and then recalculated into Tissue Preservation Index (TPI), D (Detrovitrinite: Desmocollinite), T (Telovitrinite: Telocollinite), Ti (Teloinertinite; Fusinite + Semifusinite + Sclerotinite) and Gelification index, V (Vitrinite: Telocolinite + Desmocollinite), Ti (Telocollinite: Fusinite + Semifusinite + Sclerotinite).

$$TPI = \frac{\text{Telovitrinite + Teloinertinite}}{\text{Detrovitrinite + Gelovitrinite + Inertoditrinite +}}$$

$$GI = \frac{\text{Vitrinite + Geloinertinite}}{\text{Teloinertinite + Detroinertinite}}$$

The recalculation results are ploted into the facies diagram Tissue Preservation Index (TPI) versus Gelification Index (GI). The coal seam M2 in the research area ot the southern, central, and northern parts is deposited in the transition environment, ie the limnic (Lower Delta Plain) to the wet forest swamp (Upper Delta Plain). According the maceral analysis, the coal seam M2 in the Muaraenim Formation is composed dominated by vitrinite (69-82,6%), liptinite (0,6-5,6%), inertinite (9,8-20,8%) and mineral matter pyrite (1,6-6,6%) (Table 1). Value of Tissue Preservation Index (TPI) on seam M2 shows value vary with value ranges between (0,35-1,43%). The varying prices of Tissue Preservation Index (TPI) in indicated changes in plant composition and peat type in the research area likely due to changes in deposition environment. Tissue Preservation Index (TPI) value >1indicates the high percentage of the presence of wood plants shown by the presence of abundant telocollinite maceral, while the Tissue Preservation Index (TPI) value <1 indicates maceral derived from herbaceous plants. Based on Gelification Index (GI) on seam M2 shows relatively high value ranges from (3,31-8,42%) indicating that the oxidation process does not take place predominantly, which is shown by the low inertinite content (Table 2). Diessel diagram results show that coal seam M2 in Muaraenim Formation is formed in the range Lower Delta Plain to Upper Delta Plain. The Lower Delta Plain environment is spread in limnic stages dominated by shrubs. While the Upper Delta Plain environment is formed at the wet forest swamp stage, it has a relatively high Tissue Preservation Index (TPI) value and is dominated by telocollinite. For Lower Delta Plain environment showed low Tissue Preservation Index value and Gelification value with predominantly desmocolinite maceral still affected by seawater (Fig. 7). This is evident from the presence of pyrite minerals (1,6-6,6%) in the seam M2 Muaraenim Formation indicating that the deposition of coal in the research area is influenced by rising sea levels (Fig. 8).

Table 1. Result and description of coal seam M2, Muaraenim Formation, in Kendi Hill based on maceral analysis

No.	No. CONTO	LITHOLOGY	MEAN REFLECTANT VITRINITE (% Rv random)	RANGE (%)	STANDARD DEVIATION	N	COMPONENT MACERAL (%)								MATERIAL MINERAL (%)
							V			I		L			
							D	T	S	F	Sc	R	Sb	Al	PYRITE
1	YR-CS	BB	0,45	0,40 0,48	0,02	200	39,0	35,4	7,0	-	13,4	0,6	1,6	-	3,0
2	YR-BS	BB	0,42	0,37– 0,47	0,03	200	50,4	23,4	9,0	-	9,6	1,0	1,0	-	5,6
3	YR-AS	BB	0,43	0,36- 0,50	0,03	200	46,0	31,6	10,4	-	7,4	0,6	0,6	-	3,4
4	YR-CM	BB	0,47	0,43- 0,53	0,03	200	43,0	37,4	8,6	-	8,8	0,6	-	-	1,6
5	YR-BM	BB	0,37	0,34- 0,39	0,01	200	45,0	24,0	6,4	-	14,4	1,0	2,6	-	6,6
6	YR-AM	BB	0,41	0,37- 0,44	0,02	200	66,0	16,6	3,4	-	6,4	2,6	2,0	1,0	2,0
7	YR-CU	BB	0,48	0,43- 0,54	0,03	200	61,4	13,4	9,6	-	9,0	1,0	-	1,0	4,6
8	YR-BU	BB	0,46	0,42- 0,50	0,02	200	59,0	18,6	3,4	-	11,0	1,4	1,0	0,6	5,0
9	YR-AU	BB	0,44	0,40- 0,47	0,02	200	69,0	9,0	3,6	0,6	11,0	1,0	1,4	2,0	2,4

Note :

BB = Coal	V = Vitrinite	F=Fusinite
SHC = Shaly coal	I = Inertinite	Sc = Sclerotinite
CSH = Coaly Shale	L = Liptinite	D = Desmocolinite
CS = Carbonaceous shale	T = Telecolinite	S = Semifusinite
SH = Shale	Al = Alginite	Sb = Suberinite
N = Number of measurments	PYRITE = Pyrite	R = Resinite

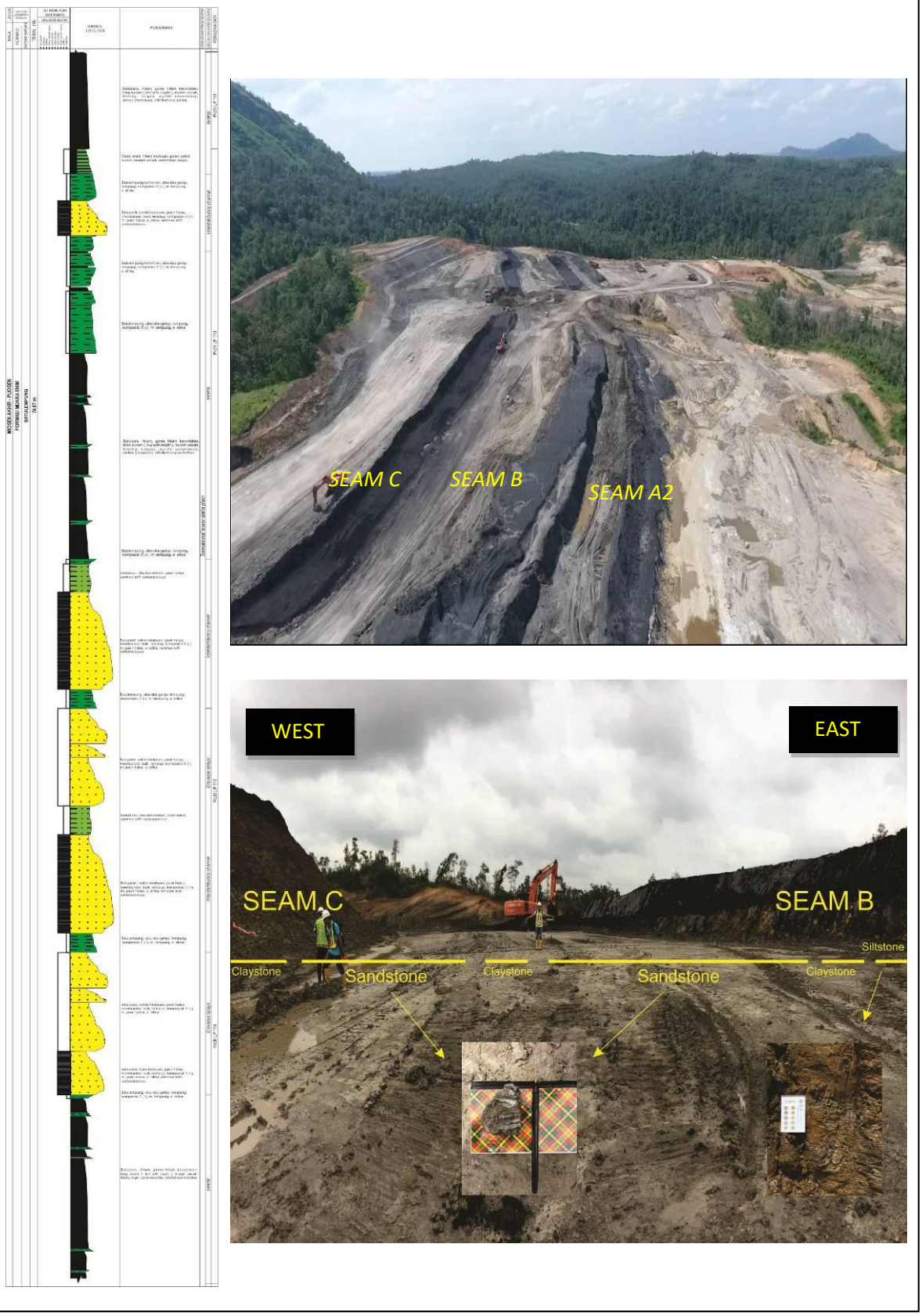

Fig. 5. Seam M2 stratigraphy column (no scale) with coal deposited on Transitional Lower Delta Plain based on Horne, 1978.

Meanwhile, the value of vitrinite reflectance of coal in the research area ranges from (0,37-0,48%) that included to the Sub-bituminous – High Volatile Bituminous C (Table 3). High percentage of vitrinite reflectance value in seam M2 is inseparable from the influence of intrusion igneous rocks in Kendi Hill, which caused the coal seams in the northern part higher than the coal seams in the central and southern part ranged from (0,44-0,48%), while the average value of vitrinite reflectance at the center is (0,37-0,47%) and in the southern is (0,42-0,45%) (Table 2).

4.2 Coal characteristics, seam M2 Muaraenim Formation in Kendi Hil

The coal outcrop in the research area is found around Kendi Hill, in Muaraenim Formation, South Sumatra as coal-bearing formation in the research area. Coal geometry at the research area is influenced by the intrusion of kendi Hill, so that the coal seam has a strike that follows kendi Hill shape and dip a relatively erect. Coal distribution at the research area is relative North West to South East and North to South (Fig. 9).

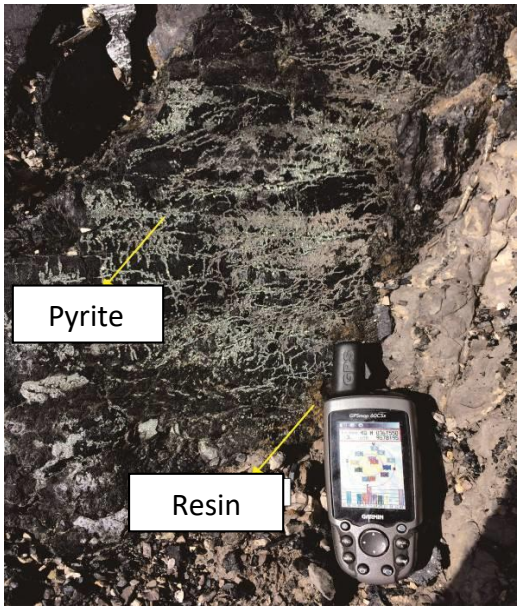

Fig. 6. The presence of pyrite and resin in coal seam M2

Coal characteristics in Kendi Hill megascopically are black, dull with bright, uneven – subchoncoidal, blackish brown in streak, have a pyrite and resin. The thickness of the coal seams ranges from 0,45 to 14 meters, which consists of seam C = 5-8meters, seam B = 11-14meters, and seam A2 = 6-7meters. The main characteristics of the main seam is seen from the presence of impurity coating on each seam in the form of silicified coal. Characteristics of seam C is the existence of silicified coal on the floor, on seam b the existence of silicified coal on the floor, and seam A2 the existence of silicified coal on the roof (Table 4). Physically the seam C is more compact than seam B and seam A2. That because seam C is in a zone closer to the intrusion of andesite in Kendi Hill so that the seam C coal layer has better quality and rank than seam B and seam A2.

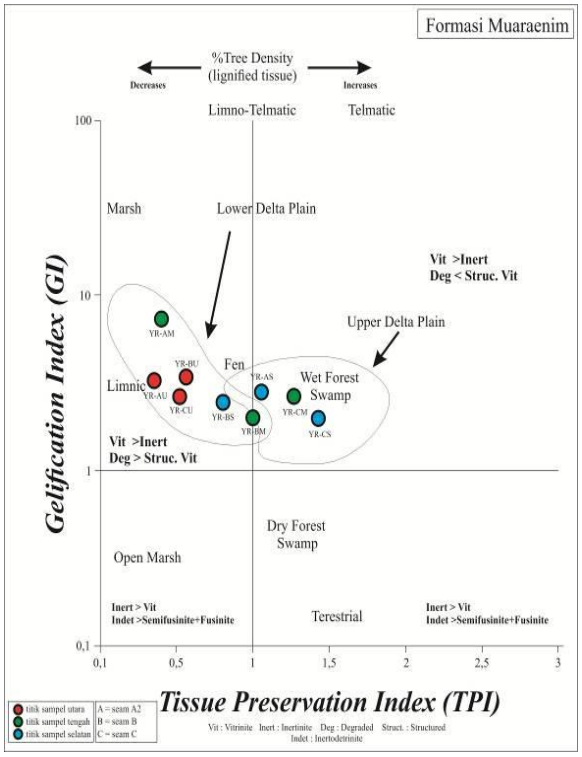

Fig. 7. TPI and GI Diagrams in research area.

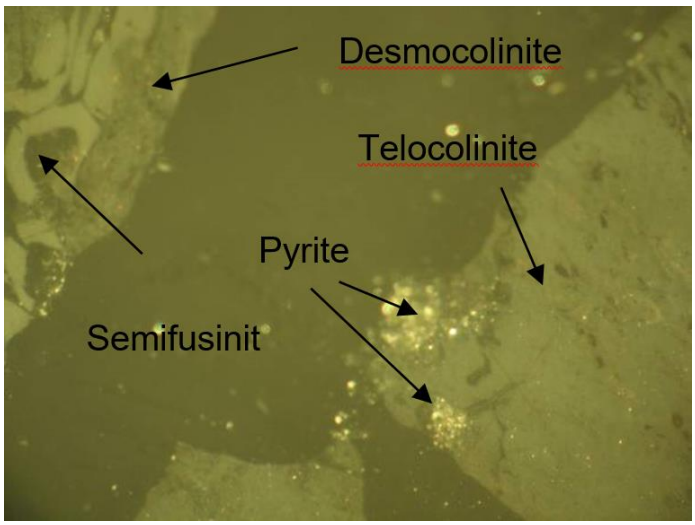

Fig. 8. Pyrite associated with telocollinite and semifusinite associated with desmocollinite, reflectance white light 500x.

Table 2. Coal rank classification according to vitrinite reflectance maximum

NO	ZONE	SAMPLE CODE	Tissue Preservation Index (TPI)	Gelification Index (GI)	Mean Refletance Vitrinite (Rv %)
1		YR-AU	0,35	5,13	0,44
2	NORTH	YR-BU	0,56	5,38	0,46
3		YR-CU	0,52	4,02	0,48
4		YR-AM	0,4	8,42	0,41
5	CENTER	YR-BM	0,99	3,31	0,37
6		YR-CM	1,27	4,62	0,47
7		YR-AS	1,07	4,36	0,43
8	SOUTH	YR-BS	0,82	3,97	0,42
9		YR-CS	1,43	3,65	0,45

Table 3. Coal rank classification according to vitrinite reflectance maximum.

RANK	MAXIMUM REFLECTANCE (%Rv max)
Subbitominous	<0.47
High Volatile Bituminous C	<0.47– <0.51
High Volatile Bituminous B	0.51– 0.71
High Volatile Bituminous A	0.71– 1.10
Medium Volatile Bituminous	1.10– 1.50
Low Vilatile Bituminous	1.50– 2.05
Semi - antrachite	2.05– 3.0 (approx)
Antrachite	> 3.0

Table 4. Description of coal characteristics seam M2.

Parameter layer	Seam A2	Seam B	Seam C
Strike/Dip	$N335^{0}E/67^{0}$	$N334^{0}E/70^{0}$	$N325^{0}E/75^{0}$
Thickness	6 – 7 m	11– 14 m	5 – 8 m
Colour	Black	Black	Black
Luster	Vitrain	Vitrain	Vitrain
Cleavage	Uneven - Subchoncoidal	Uneven - Subchoncoidal	Uneven - Subchoncoidal
Streak	Black his brown	Blackish brown	Black
Roof	Silicified coal	-	-
Floor	-	Silicified coal	Silicified coal

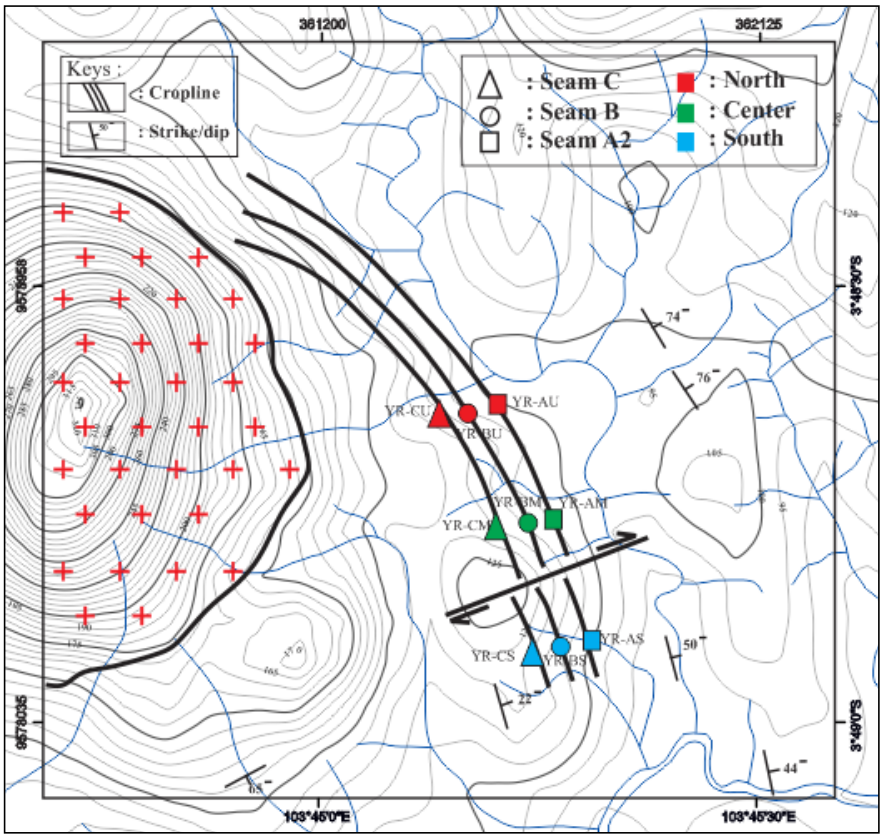

Fig. 9. Map of distribution pattern of coal layer of research area

5. Conclusions

Based on this research, it can be concluded as follows:

1. The sedimentary environment and coal bearing formation in Seam M2 Muaraenim Formation in Kendi Hill, South Sumatra based on measured stratigraphic cross section are Transitional Lower Delta Plain with sub-environment crevasse spays, swamp,and distributary channel.
2. Based on the result of maceral analysis and diagrams Tissue Preservation Index and Gelification Index Diessel conducted on nine samples of coal, it is suggested that the deposition environment of coal in the research area is transtion of Limnic (Lower Delta Plain) to wet forest swamp (Upper Delta Plain), with maceral composition consists of vitrinite (69-82,6%), liptinite (0,6-5,6%), inertinite (9,8-20,8%) and mineral matter pyrite (1,6-6,6%). Organic materials that develop in research area dominated by plants of shrubs and wood plants with type maceral telocollinite and desmocolinite.
3. The value of vitrinite reflectance coal in research area ranged from (0,37-0,48%) that included to the Sub-bituminous – High Volatile Bituminous C. The closer to intrusion andesite Kendi Hill the vitrinite reflectance is higher (northern, 0,44-0,48%) than that of coal away from the intrusion zone (center, 0,37-0,47% and southern, 0,42-0,45).
4. Coal characteristics Kendi Hill, seam M2 Muaraenim Formation are black, dull with bright, uneven – subchoncoidal, blackish brown in streak, have a pyrite and resin with The thickness of the coal seams ranges from 0,45 to 14 meters.

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