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ORGANIC PETROLOGY OF SELECTED COAL SAMPLES OF EOCENE KUARO FORMATION FROM PASIR AREA-EAST KALIMANTAN

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ABSTRACT

Eight samples of Eocene Kuaro Formation were taken from Pasir area, East Kalimantan to be examined their lithotype, maceral, mineral matter and rank of the coals in terms of geologic factors. The samples were analysed according to the ASTM (2009). The result shows the dominance of brighter lithotypes and vitrinite over liptinite, inertinite and mineral matter. There is a strong correlation between lithotype and maceral composition of the coals. The brighter lithotypes have high vitrinite content. This indicates that the coals were formed under a wet condition. The presence of high content of pyrite and calcite reflects marine incursion, in which the coals were deposited under paralic and shallow marine environment. Thus, this environment strongly supports the above correlation, where the coals were formed under the wet condition. The slight differences in the coal type can be caused by the relatively short period of peat accumulation and similarity in climate during the peat formation, and slight differences in geological setting during the Eocene period. Vitrinite reflectance ($R_v$max%) values show similar ranks (mostly subbituminous A to high volatile bituminous C) with a slight difference due to the thickness of cover during the coalification.

Keywords: organic petrology, type, rank, Pasir coals

INTRODUCTION

Indonesia has vast resources of coal deposit, which have been continuously exploited in a non-systematic manner (Yunianto *et al,* 2009; Haryadi *et al,* 2009). A lot of exploratory works have produced additional data. However, these data have not been used in integrated studies. Certainly, this is not in accordance with Law No.4 year 2009 about the mineral and coal mining. The law strongly suggests that those data must be used for integrated studies in order to apply the good mining practices to obtain maximal coal exploitation. Unfortunately, most of the works do not conduct any petrographic study. In fact, this study is quite useful to determine type and rank of coal and to delineate a zone of coalification trend. According to the above law, this zone can be applied for the mining area within a spatial land use plan. For this reason, a petrographic study has been carried out by using coal samples obtained from south-eastern part of the Kutai Basin in the Pasir area.

The main aims of the study are as follows:

a. to evaluate coal type and rank variation,
b. to determine type and abundances of mineral matter,
c. to interpret lithotype, maceral and mineral matter according to geologic factors.

METHODOLOGY

Eight coal samples from the Pasir area were analysed. The sampling was in accordance with the ASTM (2009). The samples were prepared as polished particulate coal mounts and analysed using incident white light and fluorescence mode microscopy. The coal petrographic terms and the

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classification used follow the ASTM (2009) as well.

The point-counts of approximately 500 points for each block were obtained. Traverses were made perpendicular to the gravitational settling direction during mounting of the polished blocks. In general, point count techniques were applied for maceral analysis. The maceral data were calculated as follows:

- mineral matter counted : vitrinite + liptinite + inertinite + mineral matter = 100%;
- mineral matter free basis : vitrinite + liptinite + inertinite = 100%.

The measurement of maximum reflectance of vitrinite follows the ASTM (2009). The stage of the microscope was rotated to obtain the first maximum reading and then rotated through approximately 180° for the second maximum reading. Each pair of readings was averaged and the mean calculated to provide mean maximum vitrinite reflectance in oil immersion (Rvmax%). The measurements were made on telo-, detro- and gelovitrinite maceral subgroups. The number of measurements on each vitrinite subgroup is based on the proportion of each subgroup in the sample as determined by point counting.

GEOLOGY

According to Darman and Sidi (2000) and Geological Agency (2009), the Kutai Basin is the largest (165,000 km^2) and the deepest (12,000-14,000 m) Tertiary sedimentary basin in Indonesia, as illustrated in Figure 1. It is a passive margin and deltaic basin (Geological Agency, 2009), which is associated with the Tertiary southeast-directed subduction zone in northwest Kalimantan and developed in the eastern part of the island and the adjacent Makassar Strait. Large-scale thrusting and continuous movement of unconsolidated mudstone in the basin have been interpreted to be caused by the slightly westward movement of Sulawesi. In general terms, the sediment was deposited in the basin as regressive sequences with the area of the thickest sedimentation moving eastward.

The Tertiary sequence of the Kutai Basin overlies strongly-deformed Cretaceous rocks including an ophiolite complex, metamorphic and volcanic rocks (Hidayat and Umar, 2006). Marine sedimentary rocks underlie the Tertiary coal deposits and probably form the basement of the Tertiary basins over most of eastern Kalimantan.

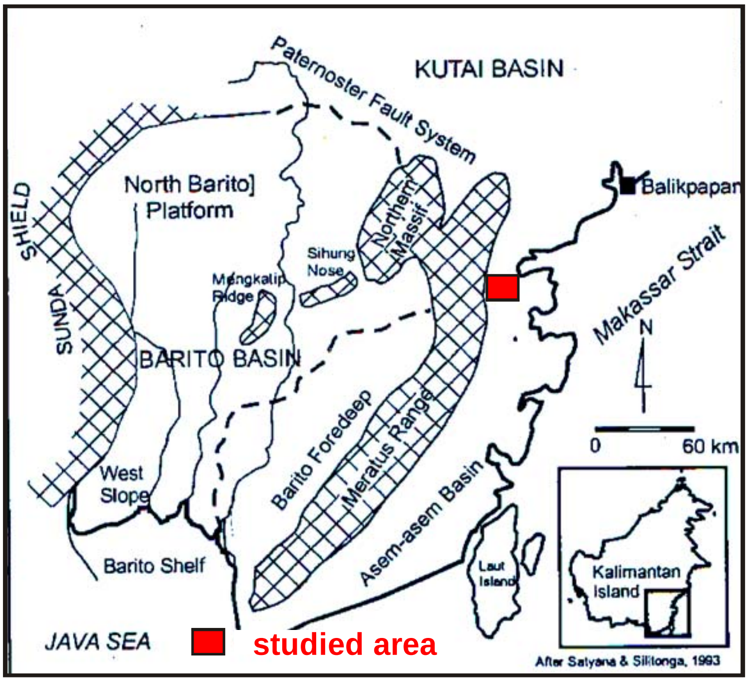

Figure 1. The Kutai Basin in southern part of Kalimantan (Darman and Sidi, 2000)

Coal deposit in Pasir area, known as the Kendilo seam, is found in Kuaro Formation, which is conformably covered by Pamaluan Formation, and is unconformably underlain by Haruyan Formation, as shown in Figure 2. The thickness of the seam varies from 4.4 to 6.9 m. The seam dips to the east at 10° to 25° (typically 14°). Significant faulting controls the coal seam geometry and may have controlled deposition of the peat prior to coalification.

banded lithotype (<5 mm).

The maceral and mineral matter data for each coal samples are listed in Table 1. Generally, organic petrological examination of the Pasir coals shows that all samples contain dominantly vitrinite (75.3% to 86.1%), sparse to major liptinite (3.3 to 15.5%), rare inertinite (0.6 to 3.7%) and relatively major mineral matter (3.5 to 11.8%). The maceral and mineral matter of the coals are presented in Fig-

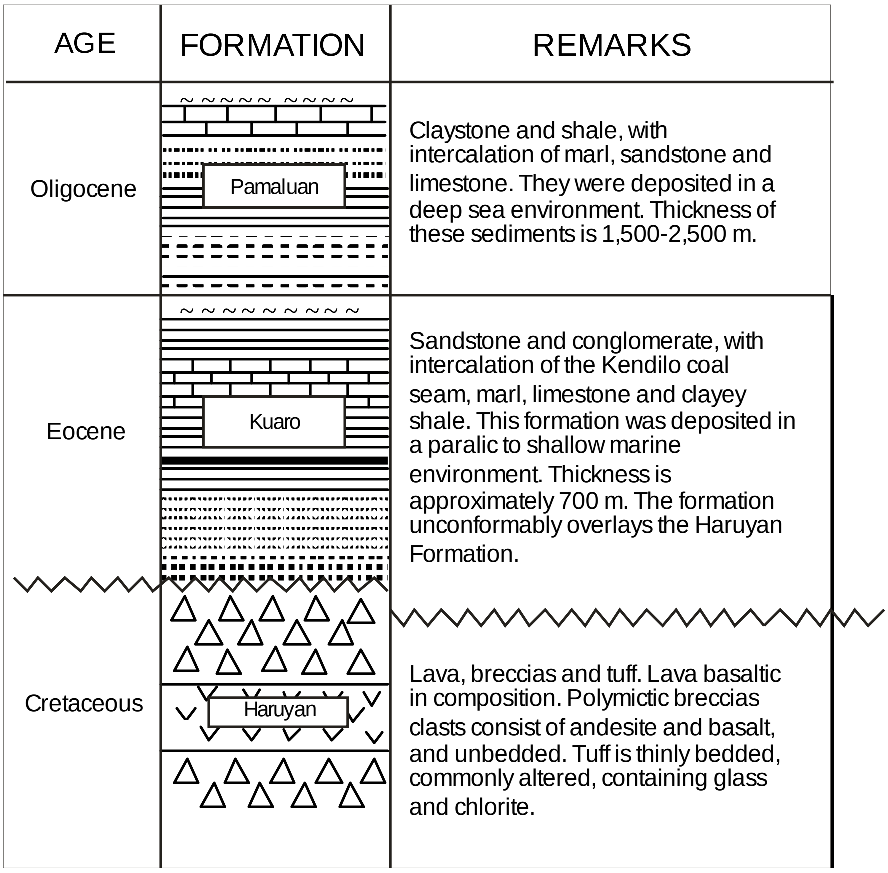

Figure 2. Stratigraphy of the Pasir area (simplified from Hidayat and Umar, 2006)

RESULTS AND DISCUSSION

Results

The organic petrology of eight coal samples of the Eocene Kuaro Formation from the Pasir area was examined for this study. Megascopically, examination of hand specimen indicates that the coals are composed mainly of bright banded and bright lithotypes. Thick bright lithotype is normally interbedded with finely-striated bands of bright

ure 3. Megascopically, clay minerals and quartz are the most common minerals in the coal samples. These minerals generally occur in partings, veins and nodules of different sizes or are disseminated throughout the coals.

In this study, vitrinite reflectance measurements were taken on all coal samples. The vitrinite reflectance ($R_v max\%$) measurement data for each samples are shown in Table 2.

Table 1. Petrographic data of the Pasir coals

No	VITRINITE (%)				INERTINITE (%)				LIPTINITE (%)							MINERAL MATTER (%)			
	TV	DV	GV	total	SF	SCL	INE	total	SPO	CUT	RES	LIP	SUB	EXS	total	C,Q	CA	PY	total
1	53.2	26.0	5.5	84.7	0.5	1.7	0.7	2.9	3.1	1.9	1.3	0.5	1.9	0.2	8.9	2.9	0.2	0.4	3.5
2	56.2	23.9	2.6	82.7	0.6	0.3	0.3	1.2	1.2	1.9	1.6	0.3	1.2	0.2	6.6	6.8	0.2	2.5	9.5
3	48.6	29.5	4.8	82.9	0.4	0.1	0.2	0.7	2.1	1.2	0.7	0.9	1.9	-	6.8	7.6	0.2	2.0	9.6
4	43.2	28.5	4.6	76.3	1.8	0.6	-	2.4	1.5	1.2	3.3	0.9	2.4	0.2	9.5	7.6	-	4.2	11.8
5	36.3	36.5	2.5	75.3	2.1	1.1	0.3	3.7	3.1	1.9	4.7	1.8	3.9	0.1	15.5	4.7	-	0.4	5.5
6	48.2	23.4	4.2	75.8	1.2	1.2	0.8	3.2	5.4	1.2	3.0	1.2	3.2	-	14.0	6.4	0.4	0.6	7.0
7	48.2	29.3	4.2	81.9	0.7	0.7	0.2	1.6	1.2	2.4	4.4	1.4	1.5	0.2	11.1	4.8	-	0.6	5.4
8	54.7	28.8	2.6	86.1	0.2	-	0.4	0.6	0.2	0.2	1.9	0.6	0.4	-	3.3	7.2	-	2.8	10.0

Notes:
TV : telovitrinite; DV : detrovitrinite; GV : gelovitrinite; SF : semifusinite; SCL : sclerotinite
INE : inertodetrinite; SPO : sporinite; CUT : cutinite; RES : resinite; LIP : liptodetrinite
SUB : suberinite; EXS : exsudatinite; C,Q : clay, quartz; CA : calcite; PY : pyrite

Table 2. Vitrinite reflectance ($R_v$max%) data of the Pasir coals

No.	TV (%)	DV (%)	VIT (%)	RANGE (%)	RANK (ASTM, 2009)
1	0.66	0.64	0.65	0.59-0.71	Subbit. A
2	0.62	0.61	0.62	0.56-0.67	Subbit. A
3	0.67	0.65	0.66	0.60-0.71	High vol. bit. C
4	0.61	0.60	0.60	0.55-0.65	Subbit. A
5	0.58	0.57	0.58	0.53-0.61	Subbit. A
6	0.62	0.57	0.60	0.54-0.69	Subbit. A
7	0.63	0.61	0.62	0.56-0.70	Subbit. A
8	0.61	0.60	0.60	0.55-0.65	Subbit. A

Notes: TV-telovitrinite; DV-detrovitrinite+gelovitrinite; VIT-vitrinite;
Subbit. A-Subbituminous A; High vol. bit. C-High volatile bituminous C

INDONESIAN MINING JOURNAL Vol. 14, No. 3, October 2011 : 146 - 153

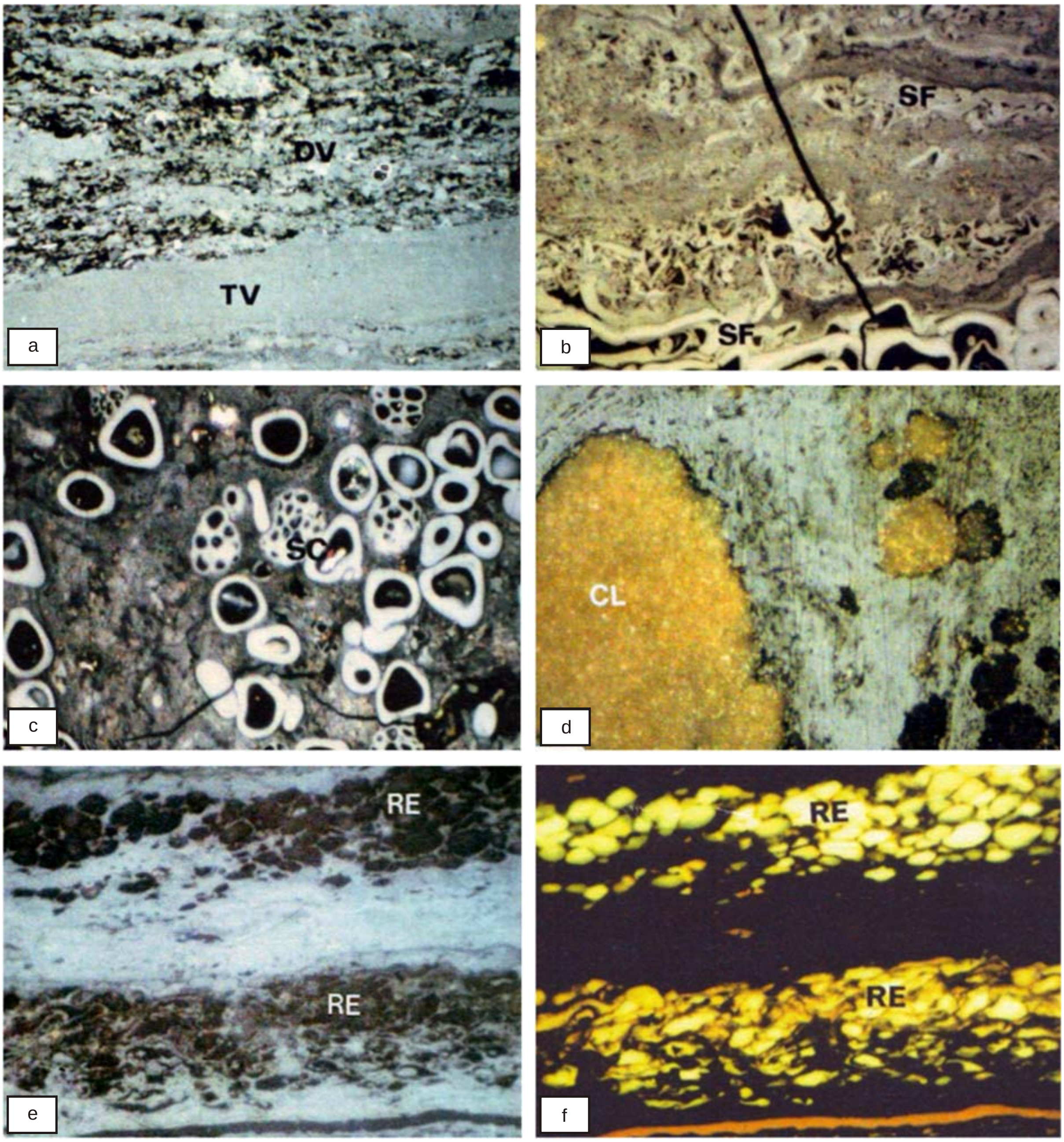

Figure 3. Maceral and mineral matter of the Pasir coals

a. Telovitrinite (TV) associated with thick detrovitrinite (DV) groundmass. Sample 7. $R_v max$=0.63%. Field width 0.36 mm, reflected white light.
b. Semifusinite (SF) associated with vitrinite. Sample 5. $R_v max$=0.58%. Field width= 0.29 mm, reflected white light.
c. Various types of sclerotinite (SC). Sample 1. $R_v max$=0.65%. Field width=0.36 mm, reflected white light.
d. Disseminated lenses of clay minerals (CL) in vitrinite. Sample 8. $R_v max$=0.61%. Field width=0.32 mm, reflected white light.
e. Diffuse cell fillings of resinite (RE) in telovitrinite. Sample 4. $R_v max$=0.60%. Field width=0.23%, reflected white light.
f. As for (e), but in fluorescence mode.

Discussion

Regarding the lithotype; megascopically, the Pasir coals are absolutely dominated by bright banded and bright types. This indicates that the coals were in association with a wet condition, which is shown by the paralic and shallow marine environment (Hidayat and Umar, 2006; Thomas, 2002; Suarez-Ruiz and Crelling, 2008; Suwarna and Kusumahbrata, 2010). This statement is also fully supported by the absence of duller lithotypes, which represent a dry condition. Therefore, the coals were formed in a marsh with wet condition under marine incursion.

Maceral composition of the coals is characterized by the dominance of vitrinite with subordinate liptinite and relatively low inertinite. This composition supports many authors who have investigated coals in eastern Kalimantan, in which most of the coals have the same maceral composition (Thomas, 2002; Whitehouse and Mulyana, 2004; Belkin *et al,* 2009; Widodo *et al,* 2010; Singh *et al,* 2010). The dominance of vitrinite in the coals is indicative of forest type vegetation in a humid tropical zone, which does not have a significant dry season (Diessel, 2010). The dominant vitrinite consists of telovitrinite and detrovitrinite. The nature of the vitrinite may be due to the presence of suberin-related tissues, which are abundant in some lithotypes. The high vitrinite content of the coals illustrates that the coals have been formed in areas of rapid subsidence.

Inertinite is low in the coals and includes predominantly semifusinite, with minor sclerotinite and inertodetrinite. This inertinite is derived from strongly oxidized, degraded wood tissue, which is indicative of dry condition during peat diagenesis (Thomas, 2002; Crosdale *et al,* 2002; Ningrum and Santoso, 2009; Diessel, 2010; Hower *et al,* 2011) , even though the overall climate may have been wet and temperate as it was during the Tertiary in Indonesia. Therefore, the relatively higher inertinite content in some coals indicates that the coal deposition occurred in a shallow basin under more aerobic condition, where the peat was frequently exposed to the atmosphere.

Liptinite is abundant in the coals comprising mainly sporinite, suberinite and resinite. This indicates that there may have been different floral assemblages at the Eocene time (Scott, 2002; Jelonek *et al,* 2007; Belkin *et al,* 2009).

Clay minerals and quartz are the most common mineral components in the coals, although a small portion of the coals contains relatively high proportion of pyrite and calcite. Depositional condition influences both lithotype and mineral composition of the coals (Ward, 2002; Turner and Richardson, 2004; Susilawati and Ward, 2006; Widodo *et al,* 2010). The coals containing fewer clay partings tend to be characterized by bright lithotypes with abundant vitrinite and lower mineral contents. This is interpreted as indicating variations in subsidence rates with rapid burial of plant material encouraging preservation of the organic matter and producing coals rich in vitrinite with fewer clay partings. Pyrite is the most abundant in the coals and occurs mostly as grains, framboids, massive nodules, veins and a replacement mineral in organic matter.

From a utilization viewpoint, the most important feature of the coals is the relatively high mineral contents, particularly pyrite. This suggests that the coals must be upgraded to eliminate or to decrease the mineral content prior to export or domestic use.

Vitrinite reflectance ($R_v$max%) values for the Pasir coals vary from 0.53 to 0.71%. This indicates that the rank of the coals is between subbituminous A and high volatile bituminous C based on the ASTM classification (2009). Differences in the vitrinite reflectance values of the coals reflect the thickness of the cover at the time of coalification, although some influence from variations in vertical rank gradients may also have had a minor effect (Thomas, 2002; Hackley and Martinez, 2007; Suarez-Ruiz and Crelling, 2008).

CONCLUSIONS

The lithotype of the Eocene Kuaro Formation Pasir coals is absolutely dominated by bright banded and bright coals, which were derived from peat accumulated under water in more reducing condition. This is undoubtedly interpreted that the coals were formed under a wet condition of the paralic and shallow marine environment.

The maceral composition of the coals is remarkably consistent in all samples. The composition is similar to most of the south-eastern part of Kalimantan, even for Indonesian coals. The characteristic of the Pasir coals is indicated by the dominance of vitrinite over liptinite and inertinite, which is indicative of forest type vegetation in humid tropical zone. The high vitrinite content of the coals is caused by rapid subsidence during the deposition.

Clay minerals, quartz and pyrite are the main mineral matter in the coals. Calcite is also available in a sparse amount. The presence of pyrite and calcite in the coals indicates that the coals were formed under a marine incursion.

Vitrinite reflectance ($R_v$max%) values of the coals ranging from 0.53 to 0.71% show that the rank of the coals is between subbituminous A and high volatile bituminous C according to the ASTM standard. All the coals have reached a similar level of coalification with no evidence of being affected by intrusion.

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