MACERAL AND MINERAL ANALYSIS OF LEBAK COALS REGARDING THEIR UTILISATION

BINARKO SANTOSO AND BUKIN DAULAY
R & D Centre for Mineral and Coal Technology
Jalan Jenderal Sudirman 623 Bandung 40211, Ph. 022-6030483, fax. 022-6003373,
E-mail :binarkos@tekmira.esdm.go.id

Received : 05 January 2007, first revision : 12 January 2007, second revision : 17 January 2007, accepted : 12 June 2007

ABSTRACT

Type and rank variations of Lebak coals were derived from twenty-eight samples of Palaeogene coalfield (Bayah, Cimandiri and Cihideung) and Neogene coalfields (Bojongmanik) using petrographic analyses. The Lebak coals are dominated by vitrinite, liptinite and minor inertinite and mineral matter as well. The coal type, in terms of maceral and mineral compositions, reflects climatic influences and differences in peat conditions. Higher vitrinite reflectance of Palaeogene coals, compared to Neogene ones, is a result of higher regional coalification level in the basin, associated with greater cover and local effect of igneous intrusion. The Palaeogene coals have better quality than the Neogenes and is also supported by higher specific energy.

The coals that are vitrinite-rich, liptinite and inertinite-poor are suitable for direct combustion.

Keywords: maceral, petrographic analysis, intrusion effect, utilization

1. INTRODUCTION

Coal deposits found in the Tertiary Lebak coalfields include Bayah, Cimandiri and Cihideung (Palaeogene); and Bojongmanik (Neogene). Some coals have been mined since the Dutch and Japanese occupations in 1892 and early1940s, respectively (Sigit, 1980). In order to illustrate the utilizations of coal deposits, coals type and rank must be obtained by petrography examination. This is also expected to fulfill the lack of coal petrography of those areas that have not been previously published. The aims of the study are:

a) to examine type and rank characteristics of the coals by conducting maceral analyses and reflectance measurements;

b) to establish the variation pattern of type and rank;

c) to examine type and rank relations to geological setting, particularly the age and intrusion effect.

2. METHODOLOGY

Twenty-eight (28) coal samples, consisting of 10 samples from Bayah, 5 from Cimandiri, 6 from Cihideung and 7 from Bojongmanik, were prepared for petrography examination based on the techniques in Coal Laboratory of Research and Development Centre for Mineral and Coal Technology. The samples were collected from borehole cores and spot samples of Tertiary Lebak coalfields (Bayah, Cimandiri, Cihideung and Bojongmanik). Procedures, preparation, terminologies and techniques used for the study are based on the Standards Association of Australia: 1964, 1966, 1975, 1977, 1981a, 1981b, 1983 and 1986. Preparation method of polished particulate coal mounts for microscopic analysis includes crushing, embedding, grinding and polishing. Microscopic examination of the polished blocks was undertaken using Leitz Orthoplan reflected light microscope fitted with fluorescence mode. Petrography analyses (maceral and mineral matter) were based on counting of 500 points using the Swift Automatic

Content

Point Counter that was attached to microscope. Maceral data were calculated as follows:

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

Measurements on vitrinite reflectance were carried out based on 100 points of each sample from which the mean random reflectance (Rvrnd) and the standard deviation (s) were calculated. Additionally, a total of 30 measurements were taken on each sample from which the mean maximum reflectance (Rvmax) and deviation (s) were also calculated.

3. GEOLOGICAL SETTING

Banten and West Java are divided into 5 tectonic provinces as follows (Keetley *et al.,* 1997; and Darman and Sidi, 2000):

- Northern basin area, a relatively stable platform area. The basin is part of Sundaland Continent and filled by Eocene-Oligocene non-marine clastics, overlain by Miocene and younger shallow shelf deposits;

- Bogor Trough composed of Miocene and younger sediments, mostly deeper water sediment gravity flow facies;

- Modern Volcanic Arc, active andesitic volcanism which is related to Indian Oceanic Plate subduction below Sundaland Continent;

- Southern slope regional uplift, mainly Eocene-Miocene sediments including volcanic rocks that belongs to Old Andesite Formation;

- Banten Block, the most western part of Java Island which is subdivided into Seribu Carbonate Platform in the north, Rangkasbitung sedimentary sub-basin and Bayah High in the south.

Tertiary Palaeogene and Neogene coals are not well developed in Java compared to those in Kalimantan and Sumatera (Koesoemadinata, 1978). Terrestrial pre-transgressive sedimentation occurred in Banten only (Figure 1) and resulted in coal deposition; whereas in Central and East Java, the sedimentation was associated with marine transgression which took place over pre-Tertiary basement.

Palaeogene coals are included in a monotonous series of quartz-sandstones (partly conglomeratic) and claystones of Bayah Formation (Figure 2). The Eocene sediments are strongly folded, particularly in Cimandiri area. In this area, coal seam dips reach up to 90° (Koesoemadinata and Matasak, 1981 The seams seldom exceed thickness of 1 m unless there is an exception that reaches to 2 m in thickness. Up to nine seams occur in some sections (Koesoemadinata and Matasak, 1981).

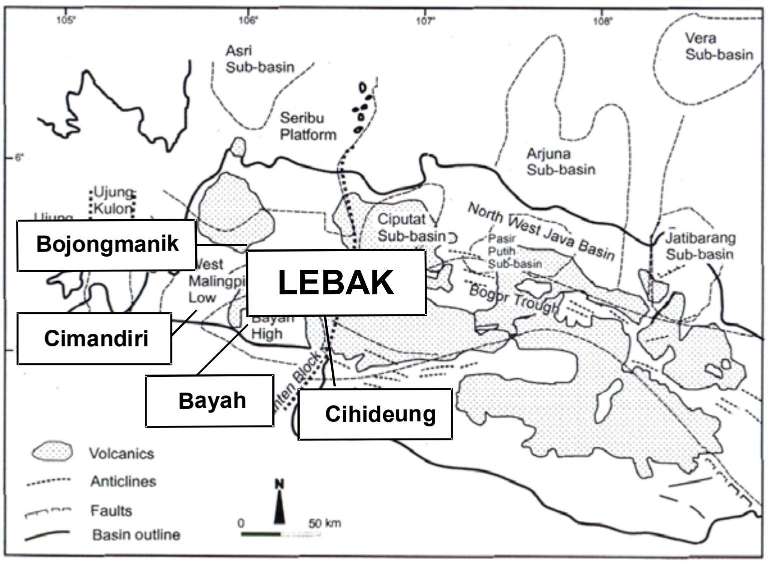

Figure 1. Tectonic map of Banten (Lebak) and West Jawa (Darman and Sidi, 2000)

Content

OROGENESIS	EPOCH	FORMATION
	HOLOCENE	COASTAL AND RIVER DEPOSITS
UPLIFT	PLEISTOCENE	PISOLITIC ANDESITE VOLCANIC PRODUCTS
	PLIOCENE	CIMANCEURI
	MIOCENE	BOJONGMANIK BADUI
FOLDED →	EARLY MIOCENE	CIMAPAG CITARATE
	LATE OLIGOCENE	UPPER CIJENGKOL
	EARLY OLIGOCENE	LOWER CIJENGKOL
VERTICAL MOVEMENT →	LATE EOCENE	BAYAH PARALIC AND MARINE FACIES
	EARLY EOCENE	

Figure 2. Stratigraphic diagram of the Lebak area (modified from Katili and Koesoemadinata, 1962)

In some localities, the coals are highly lenticular. Coals deposition occurred in paralic environment (Katili and Koesoemadinata, 1962, however, no reliable index-strata are available for correlatingvarious coal measures. In addition, some small andesite intrusions occur in Cimandiri.

Neogene coals are found in a series of claystones and sandstones of the Miocene Bojongmanik Formation. Six coal seams take place in several sections (Santoso and Ningrum, 2003). Its ranks are between brown to sub-bituminous according to the Australian classification or lignite to sub-bituminous C coals as classified by the American Standard for Testing Materials. They are commonly thin and distributed discontinuously with exception of a seam that has a thickness of 2 m. The coal are also widely distributed and associated with claystones and sandstones. Deposited in coastal-lagoon environment, its dips vary between 10 and 30º to the northwest (Siswoyo and Thayeb, 1976; Martodjojo, 1984).

4. PETROGRAPHIC ANALYSIS

Petrography analyses of twenty-eight Lebak Palaeogene (Bayah, Cimandiri and Cihideung) and Neogene (Bojongmanik) coals indicate that vitrinite is the dominant maceral over liptinite, and inertinite is rare. Mineral matter that is mainly clay and pyrite is significantly high (Table 1). Vitrinite reflectances of Palaeogene coals range from 0.53 to 0.83% (sub-bituminous to high volatile bituminous rank) while the vitrinite reflectances of Neogene coals vary between 0.34 and 0.41% (brown and sub-bituminous rank according to the Australian standard) as seen in Table 2. Vitrinite reflectance of Cihideung Palaeogene coals increases locally from 0.99 to 1.33%. This change is interpreted to be associated with igneous intrusion.

4.1. Coal type

Vitrinite of Palaeogene coals varies between 71 and 96% with average of 88% and the Neogenes ranges from 80 to 90% with average of 87%. The vitrinite occurs mostly as thick layers with a detrovitrinite matrix interbedded with thin telovitrinite layers (Figure 3). Gelovitrinite, corpovitrinite and porigelinite are present throughout the coals.

The dominant liptinite macerals within coals are resinite and cutinite. Suberinite, sporinite, liptodetrinite, fluorinite and exsudatinite are present in some samples. In Neogene samples, sporangia occur in trace amounts (Figures 4 and 5) and have greenish yellow to yellow fluorescence. Resinite is the dominant liptinite maceral, up to 7% in Neogene coals and up to 3% in Palaeogene coals. Palaeogene resinite mostly takes place as discrete small bodies (< 0.06 mm) in various shapes. In contrast, Neogene resinite is commonly concentrated in distinct layers. The resinite of both coals has greenish yellow to yellow fluorescence.

Another dominant liptinite maceral, namely cutinite, contains up to 8% in Palaeogene coals and up to 5% in Neogene coals. The macerals occurs mostly as thin cuticles and in some cases form a leaf coal (Figures 6 and 7). In both Palaeogene and Neogene coals, the cutinites show greenish yellow to yellow fluorescence. Sporinite is more abundant in Neogene coals than in Palaeogenes. Sporinite of Palaeogene coals constitutes a trace to 1%, while in Neogene coals is up to 2%. Sporinite fluorescence is greenish yellow to yellow.

Suberinite is common in Neogene coals and less common in Palaeogenes. Some suberinites of both Palaeogene and Neogene coals have a weak yellow to orange fluorescence. However, it does not fluoresce in some cases. Fluorinite is present

Content

Table 1. Maceral and mineral composition of the Lebak coals

Age	Location	Vitrinite (%)				Inertinite (%)				Liptinite (%)				MM
		Tv	Dv	Gv	Tot	Sf	Scl	Inert	Tot	Res	Cut	Sub	Tot	(%)
Palaeogene	Bayah	70	18	5	93	tr	tr	1	1	1	3	-	4	2
		60	22	5	87	1	1	1	3	tr	1	-	1	9
		36	47	5	88	tr	tr	tr	tr	1	2	-	3	8
		37	47	6	90	1	1	1	3	1	1	-	2	4
		39	48	5	92	1	1	1	3	1	1	-	2	3
		37	40	6	83	tr	tr	tr	tr	2	1	-	3	13
		44	36	8	88	-	tr	tr	tr	-	1	1	2	10
		47	33	8	88	2	1	1	4	1	1	-	2	6
		34	55	5	94	-	1	tr	1	1	3	-	4	2
		54	33	6	93	tr	tr	-	tr	1	1	-	2	4
	Cimandiri	35	41	15	91	tr	1	-	1	1	tr	-	1	7
		36	44	13	93	tr	1	-	1	1	1	-	2	3
		44	37	9	90	1	1	2	4	2	1	1	4	1
		45	33	11	89	1	1	1	3	3	1	1	5	2
		48	33	9	90	tr	1	1	2	3	1	1	5	2
	Cihideung	51	26	4	81	3	2	2	7	2	6	tr	8	4
		53	16	2	71	3	2	2	7	2	8	tr	10	10
		66	16	3	85	2	2	2	6	tr	7	tr	7	2
		82	9	1	92	1	-	-	1	-	-	tr	tr	7
		96	tr	-	96	-	-	-	-	-	-	-	-	4
		75	16	1	92	1	1	tr	2	-	-	-	-	6
Neogene	Bojong-manik	27	45	8	80	1	1	tr	2	7	5	1	13	1
		31	43	9	83	tr	1	tr	1	6	4	1	11	1
		44	37	9	90	1	1	tr	2	3	2	-	5	1
		47	35	8	90	2	1	tr	3	3	2	-	5	1
		17	53	15	85	1	1	tr	2	7	3	1	11	1
		46	35	6	87	-	1	-	1	5	4	-	9	1
		19	56	12	87	tr	1	tr	1	6	2	1	9	1

Notes: Tv : telovitrinite, Dv : detrovitrinite, Gv : gelovitrinite, Sf : semifusinite, Scl : sclerotinite, Inert : inertodetrinite, Res : resinite, Cut : cutinite, Sub : suberinite, MM : mineral matter, Tot : total

only in Neogene coals and has greenish yellow fluorescence. Liptodetrinite that is only present in Palaeogene coals has greenish yellow to yellow fluorescence. Exsudatinite is rare in both Palaeogene and Neogene coals and has strong greenish yellow to yellow fluorescence. It fills mostly in the joints.

Inertinite content of Lebak Palaeogene coals is higher than that of Neogene coals. The content comprises of semifusinite, sclerotinite and inertodetrinite. The semifusinite content of Palaeogene coals is up to 3% and in Neogene coals is up to 1%. Sclerotinite and inertodetrinite of Palaeogene coals are up to 2% and Neogene coals are up to 1%. Both macerals are scattered throughout the coals. Sclerotinite comprises of single and twin-celled teleutospores and sclerotia. Some cell lumens are filled in by mineral matter. Inertodetrinite takes place as small high reflecting particles that are less than 0.02mm.

Mineral matter of Palaeogene coals that is mainly clay and pyrite varies between 1 to10% with average of 4%. Few samples contain up to 13% mineral matter. The mineral matter in Neogene coals constitute to 1%. Clay and pyrite mostly occur as pods and disseminated throughout the coals. In some cases, they fill in the cell lumens. Pyrite consists of framboidal and massive grain structures. In summary; vitrinite, liptinite and inertinite contents of Lebak Palaeogene and Neogene coals are systematically related to each other. Liptinite and

Content

Table 2. Rank of the Lebak coals (Australian standard)

Age	Location	Rank
	Bayah	High volatile bituminous High volatile bituminous High volatile bituminous High volatile bituminous High volatile bituminous High volatile bituminous High volatile bituminous High volatile bituminous High volatile bituminous High volatile bituminous
Palaeogene	Cimandiri	High volatile bituminous High volatile bituminous High volatile bituminous High volatile bituminous High volatile bituminous
	Cihideung	Sub-bituminous Sub-bituminous Sub-bituminous Sub-bituminous Medium volatile bituminous High volatile bituminous
Neogene	Bojongmanik	Sub-bituminous Sub-bituminous Brown coal Brown coal Brown coal Brown coal Brown coal

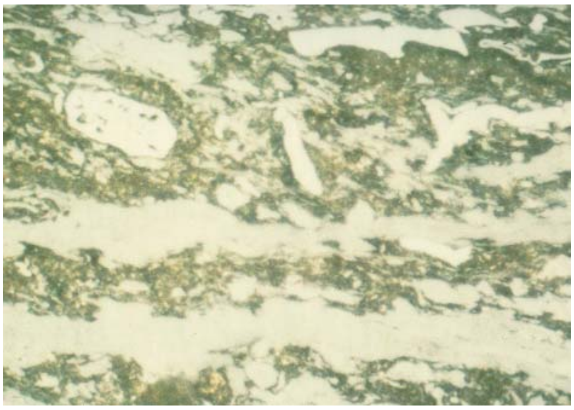

Figure 3. Telovitrinite (grey, intact) interbedded with detrovitrinite (grey, broken) and clay (brownish-grey). Rvmax: 0.70%, field width: 0.28mm, reflected white light

Figure 4. Sporangia (brownish-grey) associated with resinite (dark grey) and detrovitrinite (grey). Rvmax: 0.36%, field width: 0.22mm, reflected white light

Content

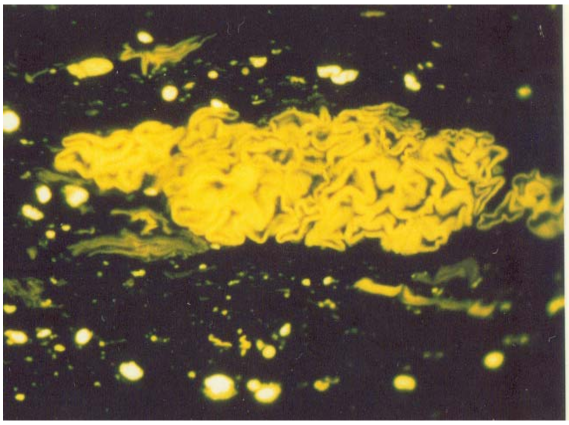

Figure 5. As for figure 4, but in fluorescence mode

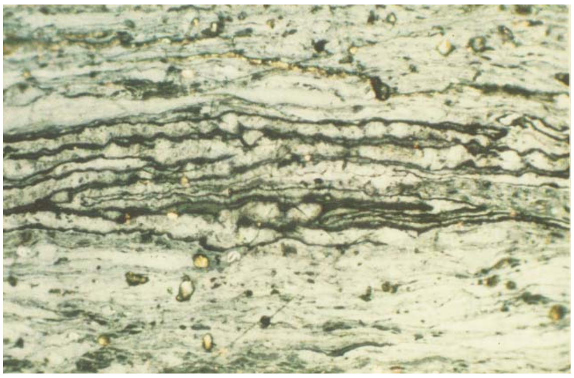

Figure 6. Cutinite (black) and telovitrinite (grey). Rvmax: 0.64%, field width: 0.44mm, reflected white light

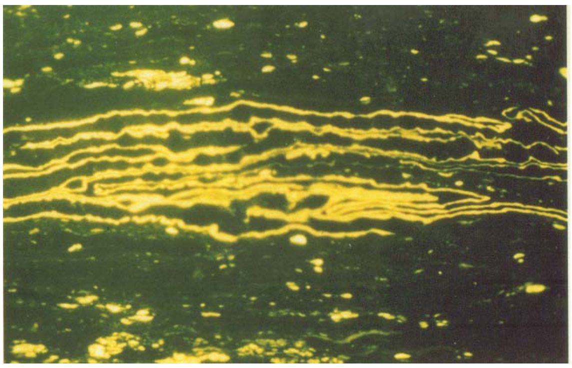

Figure 7. As for figure 6, but in fluorescence mode

inertinite contents decrease with the increase of vitrinite content. The liptinite content tends to increase in inertinite content (Figures 8a, 8b and 8c).

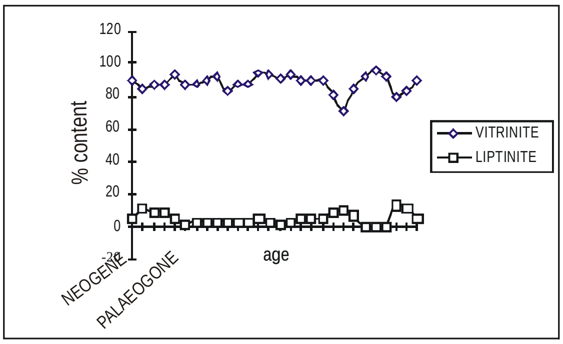

Figure 8a. Relation between vitrinite and liptinite contents of the Lebak coals

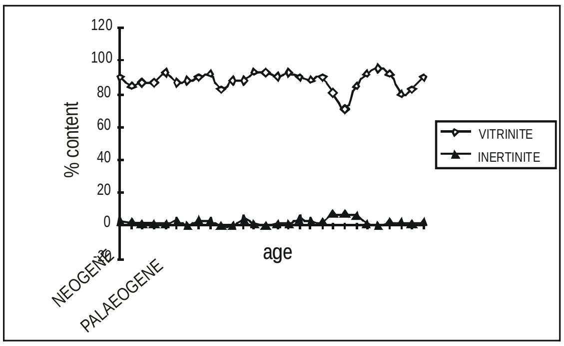

Figure 8b. Relation between vitrinite and inertinite contents of the Lebak coals

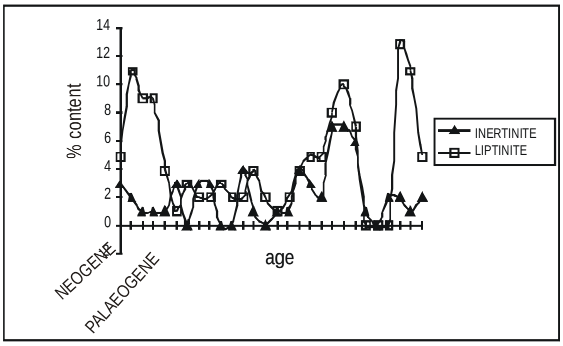

Figure 8c. Relation between inertinite and liptinite contents of the Lebak coals

4.2. Coal rank

Lebak Palaeogene coals range from sub-bituminous to high volatile bituminous in which vitrinite reflectance (Rvmax) varies between 0.53% and

Content

0.83%. Vitrinite reflectances vary between the studied areas. For instance, Rvmax of Palaeogene coals in Bayah (0.60 to 0.79%) is higher than that of Palaeogene coals in Cihideung (0.53 to 0.56%). Yet the vitrinite reflectance of Palaeogene coals in Cihideung area increases locally (ranging from 0.99 to 1.23%) due to igneous intrusion. In Cimandiri area, the Rvmax increases from 0.64 to 0.83%). Higher vitrinite reflectance in this area is due to the presence of an igneous/dioritic intrusion.

Lebak Neogene coals are lower in rank (brown coal to sub-bituminous) with vitrinite reflectance between 0.34 to 0.41%. In summary, vitrinite reflectance of Neogene and Palaeogene sequences increases from top to bottom. These changes are caused by huge thickness of cover over the lower coals. Same trend is reported by Bemmelen (1970) and Roeslan (1984) who pointed that the specific energy increases from Neogene to Palaeogene coals (Table 3).

tent of mineral matter. The coal seams deposited in areas of rapid subsidence have both high vitrinite and high mineral contents that are present as discrete dirt bands as mentioned by Cook (1975) and Shibaoka and Smyth (1975).

The Lebak coals indicate variable vitrinite reflectances due to age and intrusion factors. The Neogene and Palaeogene coals have vitrinite reflectances ranging from 0.34 to 0.41% and 0.53 to 0.83% respectively. Even in Cihideung area, vitrinite reflectances of Palaeogene coal vary between 0.99 and 1.23%. The Palaeogene coals (Cimandiri, Bayah and Cihideung areas) comprise of thermally altered coals. In these areas, a more rapid and thorough alteration has taken place where bodies of igneous/dioritic rocks have intruded the Tertiary sequences. Consequently, lower rank coal has been metamorphosed to bituminous or even anthracitic rank. The extent of rank increase depends on coal distance from igneous rock intrusion as well as intrusion size and temperature. The extent of gas or liquid streaming away from intrusion is also significant.

Table 3. Relationship of vitrinite reflectance/rank to specific energy of Lebak coals

Age	Specific Energy (kcal/kg)	Rv_{max} (%)	Rank
Neogene (Bojongmanik)	4,67	0.34 - 0.41	Brown coal-Sub-bituminous
Palaeogene (Bayah, Cimandiri, Cihideung)	5,652 - 6,778	0.53.0.83	Sub-bituminous-High volatile bituminous

5. DISCUSSION

Maceral compositions in various Lebak Tertiary coal samples are slightly different from one to anotherdue to intrusion effect and age. The most obvious trend for the Lebak coals is the decrease in liptinite and the increase in vitrinite contents from Neogene to Palaeogene. Vitrinite in unaffected, contact-alteration coals comprises of thick detrovitrinite matrix that is interbedded with thin bands of telovitrinite. In some cases, thin bands and lenses of telovitrinite are isolated in detrovitrinite matrix. Vitrinite of thermally affected coals is mostly structureless, massive and contains few pores.

The dominance of vitrinite within coals indicates forest type vegetation in a humid tropical zone without significant dry events throughout the zone. Vitrinite-rich coal, in some cases, has a high con-

Relationship between vitrinite reflectance and carbon content and specific energy is aparent in both Palaeogene and Neogene coals. In general, carbon content and specific energy of Palaeogene coals are higher than those of Neogene coals. Therefore, the Palaeogene coals are better quality than the Neogenes.

Vitrinite-rich coals are suited for direct combustion because they are easy to grind through finer fractions (Edwards and Cook, 1972). Similar to this, liptinite-poor coals are also easy to grind and are commonly concentrated in finer sizes (Neavel, 1981). Most of the coals containing high pyrite (>1%) tend to be prone to spontaneous combus-

Content

tion. Combustion systems for coals, which in general contain less than 10% inertinite macerals, can therefore operate with normal combustion temperatures. The normal temperature is approximately 1,400°C as stated by Shibaoka (1969). Some lower rank coals with high moisture contents (Bojongmanik) will provide problems if used for spontaneous combustion as the moisture levels will promote low heating values (Roeslan, 1984).

6. CONCLUSIONS

Type and rank characteristics of Lebak coals indicate the influence of age and intrusion factors. The coals type reflects the influence of peat environment and climate. Rank variation results from contrasting burial and palaeotemperature histories. The palaeoclimate of Lebak throughout the Tertiary was humid and tropical. Lebak peats developed with the establishment of tropical forest. Paleocene coals were deposited in fore-arc basin or continental margin basins and are interbedded with lacustrine and fluvial deposits while Neogene coals were deposited in back-arc basin and were associated with limnic-paralic deposits.

Vitrinite is the dominant maceral in Lebak coals. It consists of detrovitrinite and telovitrinite and some minor gelovitrinite. Liptinite is common in the coals. Resinite is the dominant liptinite maceral in the coals, although cutinite and suberinite are dominant in some occurrences. Sporinite and liptodetrinite are common. Fluorinite and exsudatinite are rare in the coals. Inertinite of the coals include semifusinite, sclerotinite and inertodetrinite. Mineral matter consisting mainly of clay and pyrite is rare in the coals.

The low proportion of inertinite in the coals suggests the low extent of oxidation/wet event during the peat stage. High proportions of vitrinite in the coals indicate that the original plant material consists essentially of woody plant tissues and the peatification occurred under relatively wet reducing conditions.

Lebak Neogene coals are typically much lower in rank than the Palaeogene coals. The Lebak coals that are not affected by contact alteration have vitrinite reflectance between 0.53 and 0.83% whilst the Neogene coals range from 0.34 to 0.41%. In Cihideung area, the coal seams are locally altered by igneous activity that has resulted higher rank coals (Rvmax of 0.99% to 1.23% or bituminous to anthracite rank).

The Lebak coals that are vitrinite-rich, liptinite and inertinite-poor coals are generally suited to use for direct combustion, because the coals are easy to grind through the finer fractions. Most of the Palaeogene coals containing high pyrite (>1%) tend to be prone to spontaneous combustion. Combustion systems for the coals can operate with normal combustion temperatures.

REFERENCES

Bemmelen, R.W. van, 1970. *The geology of Indonesia, vol.II, economic geology.* Martinus Nijhoff, The Hague.

Cook, A.C., 1975. The spatial and temporal variation of the type and rank of Australian coals. In: Cook, A.C. (ed.), *Australian black coal-its occurrence, mining, preparation and use,* Wollongong.

Darman, H. and Sidi, F.H., 2000. *An outline of the geology of Indonesia.* Indonesian Association of Geologists. Jakarta.

Edwards, G.E. and Cook, A.C., 1972. The design of blends for the production of metallurgical coke, with particular reference to long term aspects of using NSW coals. *Proceedings of Australasian Institute of Mineral and Metallurgy, 244.*

Katili, J.A. and Koesoemadinata, R.P., 1962. *Structural pattern of South Banten and its relation to the ore-bearing veins.* Department of Geology, University of Indonesia, Bandung.

Keetley, J.T., Cooper, G.T., Hill, K.C., Kusumahbrata, Y., O'Sullivan, P.B. and Saefudin, I.I., 1997. The structural development of the Honje High, Bayah High and adjacent offshore shares, West Jawa, Indonesia. In: Howes, J.V.C. and Noble, R.A. (eds), *Proceedings of an international conference on Petroleum Systems of SE Asia and Australasia.* Indonesian Petroleum Association.

Koesoemadinata, R.P., 1978. Sedimentary framework of Tertiary coal basins of Indonesia. *3rd Regional Conference on Geology and Mineral resources of Southeast Asia, Bangkok, Thailand.*

Content

Koesoemadinata, R.P. and Matasak, T., 1981. Penelitian endapan batubara di sekitar Bayah-Jawa Barat. *Institut Teknologi Bandung.* Bandung.

Martodjojo, S., 1984. Evolusi Cekungan Bogor. *Disertasi Doktor.* Jurusan Geologi ITB, Bandung (tidak dipublikasikan).

Neavel, R.C., 1981. Origin, petrography and classification of coal. In: Elliot, M.A. (ed.), *Chemistry of coal utilisation.* New York.

Roeslan, K., 1984. The coal resources of Indonesia and Southeast Asia. *AGID-ILP Workshop, 7th AGC,* Sydney.

Santoso, B. and Ningrum, N.S., 2003. Karakteristik batubara Bojongmanik berdasarkan analisis megaskopis, petrografis dan proksimatnya. *Prosiding Kolokium Energi dan Sumber Daya Mineral 2003.* Puslitbang *tek*MIRA, Bandung.

Shibaoka, M., 1969. An investigation of the combustion processes of single coal particles. *Institute of Fuel Journal, 42.*

Shibaoka, M. and Smyth, M., 1975. Coal petrology and the formation of coal seams in some Australian sedimentary basins. *Economic Geology 70.*

Sigit, S., 1980. Coal development in Indonesia, past performance and future prospects. In: Mangunwidjaja, A.S. and Hasan, O. (eds), *Coal Technology.* Proceedings of Seminar on Coal Technology and the Indonesian needs. Jakarta.

Siswoyo and Thayeb, E., 1976. *Formasi Bojongmanik-suatu satuan litostratigrafi di Jawa Barat.* Lemigas, Jakarta.

Standards Association of Australia, 1964. Australian standard code of recommended practice for taking samples from coal seams in situ. *AS CK5.*

Standards Association of Australia, 1966. Glossary of terms for coal and coke. *ASK 149.*

Standards Association of Australia, 1975. Methods for the analysis and testing of coal and coke: reporting of results. *AS 1038 (16).*

Standards Association of Australia, 1977. Code of practice for preparation of hard coal samples for microscopical examination by reflected light. *AS 2061.*

Standards Association of Australia, 1981a. Determination of the maceral group composition of bituminous coal and anthracite (hard coal) *AS 2515.*

Standards Association of Australia, 1981b. Microscopical determination of the reflectance of coal macerals. *AS 2486.*

Standards Association of Australia, 1983. Guide for the taking of samples from hard coal seams in situ. *AS 2617.*

Standards Association of Australia, 1986. Coal maceral analysis. *AS 2856.*

Content