PETROGRAPHIC ANALYSES OF COAL DEPOSITS FROM CIGUDEG AND BOJONGMANIK AREAS WITH REGARD TO THEIR UTILISATION

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ABSTRACT

Geological setting of the Cigudeg and Bojongmanik areas gives rise to the coal characteristics, particularly due to the depositional environment and stratigraphic aspect. Those characteristics include lithotype, type and rank of the coals. The coals formed under wet-swamp condition to result in brighter lithotype and vitrinite-rich coal. By contrast, the coals formed under dry-swamp condition to result in duller lithotype and inertinite-rich coal. The Cigudeg coals contain clay minerals and quartz, whilst the Bojongmanik coals contain pyrite and calcite. These minerals are beneficial to interpret depositional environment of the coals. Ranks of the Bojongmanik coals are somewhat higher (lignite-subbituminous C-B) that those of the Cigudeg coals (lignite-subbituminous B) according to the ASTM classification. These higher ranks are due to the thicker overburden on the Bojongmanik coals in terms of stratigraphic aspect.

Regarding those petrographic characteristics, both coals are suitable for fuel of direct combustion for the small-scale and home industries that are available in the surrounding areas. Therefore, the coals can economically cope with the demand of those industries.

Keywords: petrographic analyses, Cigudeg coals, Bojongmanik coals, utilisation

1. INTRODUCTION

Coal deposits are found in many locations in Java Island that are distributed from western to eastern part of the island. Resources of the coals are approximately 14,210,000 tons (Hadiyanto, 2006). Most of the coals are located in Banten, and some have been mined since the Japanese occupation in 1940s, particularly in Bayah Coalfield in southern Banten (Sigit, 1980). Unfortunately, research on coal petrography is rarely carried out in Indonesia due to lack of the apparatus facilities and capability of the human resources. Few coal petrologists have been researching for coal in this country since late 1980s, particularly in determining type and rank of coal with respect to its utilisation. In addition, some overseas enterprises for oil and gas exploration have also tried to conduct it since 1985, particularly in observing exinite macerals as oil-source rocks (Santoso and Ningrum, 2003).

Cigudeg (Bogor Regency, West Java) and Bojongmanik (Lebak Regency, Banten) areas were selected for the studied areas, because both areas significantly contain six coal seams that were geologically investigated by Siswoyo and Thayib (1976), Martodjojo (1984), Jusmady (1987) and Santoso and Ningrum (2003). However, these investigations were not supported by coal petrography and accordingly, the presented data were not complete, especially in association with the coal geological issues. Besides, type and rank of the coals is unknown that are significant to utilise.

Regarding the lack of data of coal petrography, attempts have been conducted to contribute and complete coal references particularly its utilisation for small-scale and home industries as fuel of direct combustion where the coal is urgently required by the industries around the studied areas.

The aims of this study are to obtain an understanding of the aspects as follows:

- Analysing type and rank of the Late Miocene Cigudeg and Bojongmanik coals of the Bojongmanik Formation by making maceral analyses and reflectance measurements,
- Examiningrelation of type and rank to geological setting, and
- Examining the implication of the petrographic data with regard to the utilisation of the coals.

2. METHODS

Thirty coal samples studied were collected from Late Miocene coals of the Cigudeg (eleven samples) and the Bojongmanik (nineteen samples) areas according to the procedure of the Standards Association of Australia (1964). These samples were then examined in reflected white light and reflected ultraviolet light excitation in the laboratory of coal petrography, Research and Development Centre for Mineral and Coal Technology, Bandung. Maceral analyses were determined in oil immersion in reflected plane polarised light at a magnification of x500 (Standards Association of Australia, 1986). The exinite group of macerals was accurately studied using ultraviolet light excitation at a magnification of x500. An orthoplan microscope fitted with a Leitz Vario-Orthomat camera was used for all photography.

Reflectance measurements were conducted using a Leitz Ortholux microscope fitted with a Leitz MPV 1 microphotometer. The microphotometer was calibrated against synthetic garnet standards of 0.917% and 1.726% reflectance and a synthetic spinel of 0.413% reflectance (Standards Association of Australia, 1981).

Normal point count techniques were applied for maceral analysis. The maceral analysis is based on counting of 500 points using the Swift Automatic Point Counter attached to the microscope. The maceral data are calculated as follows:

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

After completion of the analysis, maceral group or mineral was expressed as a percentage of the total points recorded. Each point could be examined in reflected white light and fluorescence mode.

Photomicrographs of macerals and mineral matter in the coals were obtained using the Leitz Vario-Orthomat camera.

Reflectance measurements were made on vitrinite, because it undergoes changes consistently with rank Vitrinite shows some inherent variability in reflectance according to type. It is the most abundant maceral in most coals and occurs as relatively large particles, thereby enabling easy measurement. The Standards recommend taking 100 measurements to obtain a precise mean value. The result of the measurements is called the mean maximum vitrinite reflectance.

3. GEOLOGICAL SETTING

Tectonically, Western Java region points the transition between frontal subduction beneath Sumatera to the west (Tapponier *et al.,* 1982; Martodjojo, 1989; Keetley *et al.,* 1997). This region has continuously been active since rifting in the Eocene. The rifting was probably related to the collision between India and Asia and resulted in a significant influx of coarse clastic sediments. The Oligocene-Recent history is more dominated by subduction-related volcanism and limestone deposition. Java Island consists of Seribu Carbonate Platform in the north, Rangkasbitung sedimentary sub-basin and Bayah High in the south.

The sediments in Banten and West Java comprise non-marine/continental sedimentary sequences and marginal marine and marine sedimentary sequences. Generally, the Tertiary coals are not well distributed in Java as mentioned by Koesoemadinata, 1978). Terrestrial pre-transgressive sedimentation occurred in West Java only, particularly in southern part of Banten and West Java, and resulted in coal deposition within the Bayah (Palaeogene) and Bojongmanik (Neogene) Formations. According to Rusmana *et al.* (1982) and Sujatmiko and Santoso

(1985), Late Miocene Bojongmanik Formation comprises alternation of sandstone and claystone, limestone and tuff. This formation is divided into three members, which are Claystone Member with coal interbed, Limestone Member and Sandstone Member with coal interbed. The formation having a thickness of 600-800 metres was deposited in shallow neritic-brackish environment in Cigudeg and Bojongmanik areas where the sea developed to the west (Darman and Sidi, 2000; **Figure 1**). Coal deposits are widely distributed in both areas include six seams know as seams A to F within the Claystone Member (Jusmady, 1987; **Figures 2** and **3**). Thicknesses of the Cigudeg coals vary from 0.2 m to 0.4 m, whilst the Bojongmanik coals are from 0.15 m to 1.9 m. The Bojongmanik Formation conformably covers Middle Miocene Badui Formation at the Bojongmanik area. The Badui Formation consists mainly of reef limestones.

Structurally, both areas have folding and faulting at the Middle Miocene deposits. The folding has west-east direction, whilst the faulting, mainly horizontal fault, has southwest-northeast direction. In line with the forming of these structures, dacite and andesite intrusions occurred in the eastern part of the Cigudeg area. However, these intrusions had no contact to the coal seams.

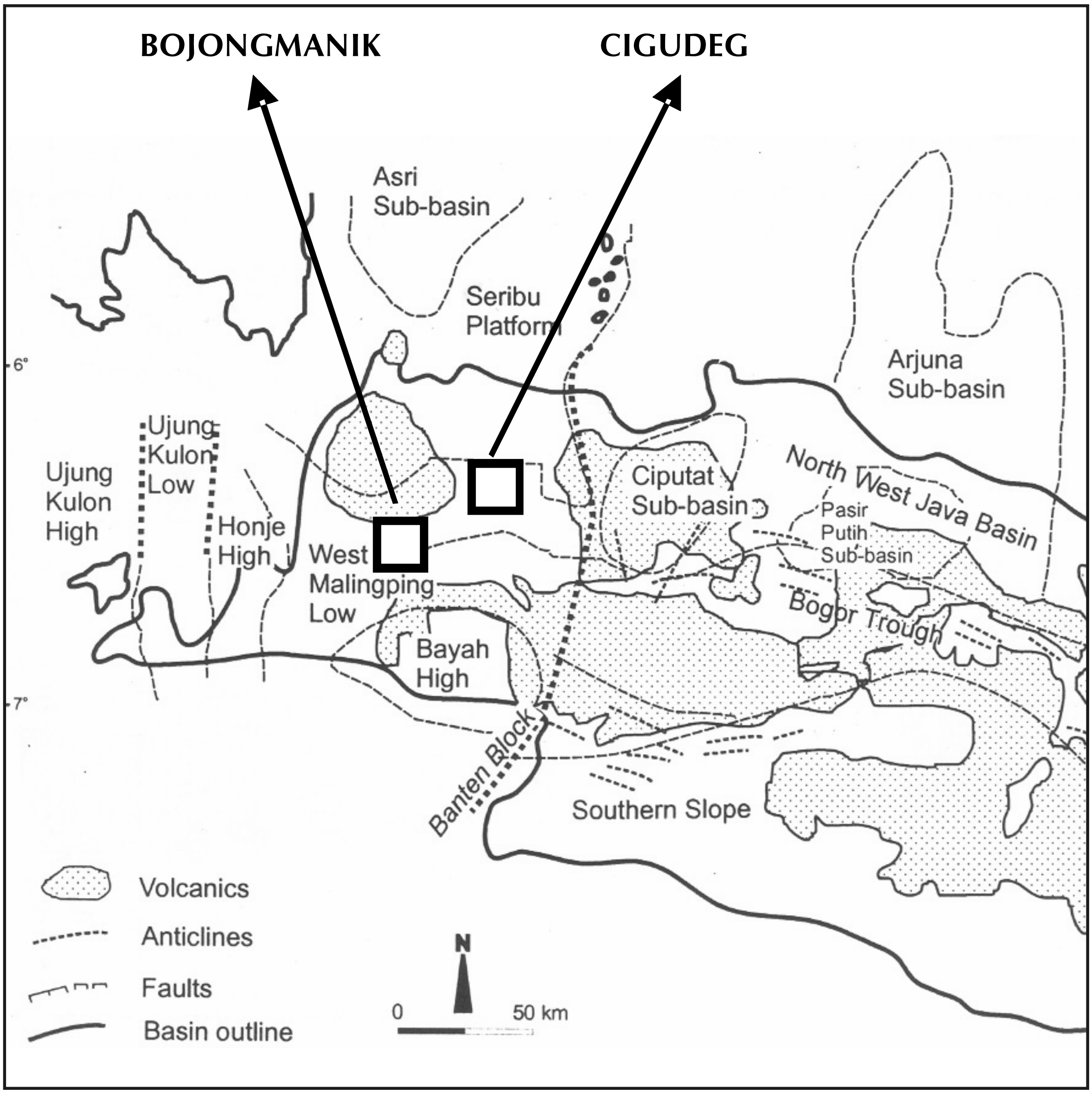

Figure 1. The studied areas at Cigudeg and Bojongmanik (Darman and Sidi, 2000)

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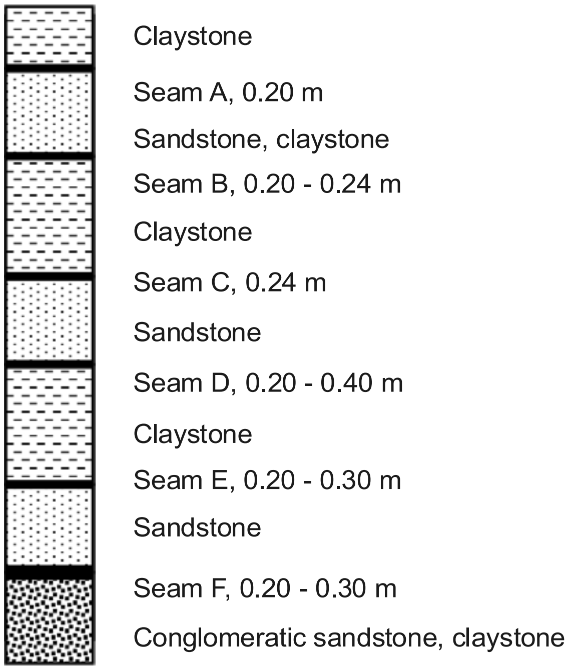

Figure 2. The Cigudeg coal seams (not to scale).

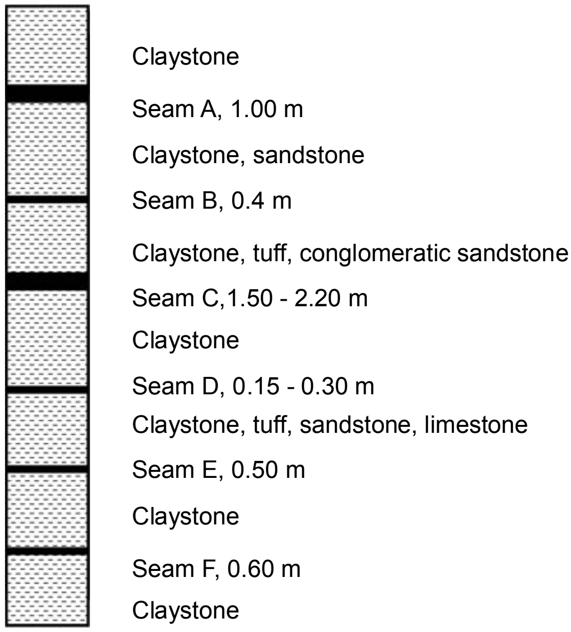

Figure 3. The Bojongmanik coal seams (Jusmady, 1987; not to scale)

4. RESULTS AND DISCUSSION

4.1. Results

Megascopically, the Cigudeg and Bojongmanik coals are dominated by brighter lithotypes, particularly for the Bojongmanik coals (**Tables 1** and **2**). In the Bojongmanik coals, most of the coal seams are bright lithotype with the exception of seams B and D. Whilst in the Cigudeg coals, the lower seams (D,E and F) are brighter lithotype and the upper ones (A, B and C) are duller lithotype.

Microscopically, both of the coals are absolutely dominated by vitrinite over inertinite, exinite and mineral matter (**Figures 4, 5, 6** and **7**).Vitrinite content is higher in the lower Cigudeg coals (D, E and F) than those of the upper ones (A, B and C); whilst in the Bojongmanik coals, its content is high in seams C, E and F.Inertinite content shows relatively high in the upper seams (A and B) of the Cigudeg coals and seam D of the Bojongmanik coals.The rest are relatively low in both coals. Exinite content is relatively low in both coals.

Table 1. Cigudeg coals

COAL SEAMS	LITHOTYPE (%)	MACERAL (%)			MINERAL (%)	Rvmax (%)	RANK	
		V	E	I			Australia	ASTM
A	60 DB, 40 DB	69.1	5.6	12.8	12.5	0.2470-0.3255	Brown coal	Lignite
B	50 BD, 50 DB	67.9	7.6	11.7	12.8	0.2909-0.3376	Brown coal	Lignite
C	100 DB	79.0	2.6	6.4	12.0	0.2804	Brown coal	Lignite
D	70 BB, 30 BD	80.1	3.2	7.1	9.6	0.3439-0.3915	Brown coal	Lignite-Subbituminous B
E	50 BD, 50 DB	81.9	5.7	7.5	4.9	0.2955-0.3516	Brown coal	Lignite
F	70 BB, 30 BD	86.6	3.0	5.1	5.3	0.3559-0.3948	Brown coal	Lignite-Subbituminous B

Notes: D-dull, DB-dull banded, BD-banded, BB-bright banded, V-vitrinite, E-exinite, I-inertinite, ASTM-American Standard for Testing Materials

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Table 2. Bojongmanik coals

COAL SEAMS	LITHOTYPE (%)	MACERAL (%)			MINERAL (%)	Rvmax (%)	RANK	
		V	E	I			Australia	ASTM
A	100 B	68.2	10.1	15.7	6.0	0.3721-0.3756	Brown coal	Subbituminous C
B	50 B, 50 D	55.3	1.1	5.0	38.6	0.3106-0.3312	Brown coal	Lignite
C	100 B	84.6	3.8	5.1	6.5	0.3721-0.3918	Brown coal	Subbituminous C-B
D	75 D, 25 B	49.2	2.6	24.1	16.1	0.3027-0.3165	Brown coal	Lignite
E	100 B	78.0	2.8	5.9	13.3	0.3623-0.3789	Brown coal	Subbituminous C
F	100 B	74.2	3.4	8.4	14	0.3795	Brown coal	Subbituminous B

Notes: D-dull, DB-dull banded, BD-banded, BB-bright banded, B-bright, V-vitrinite, E-exinite, I-inertinite, ASTM-American Standard for Testing Materials

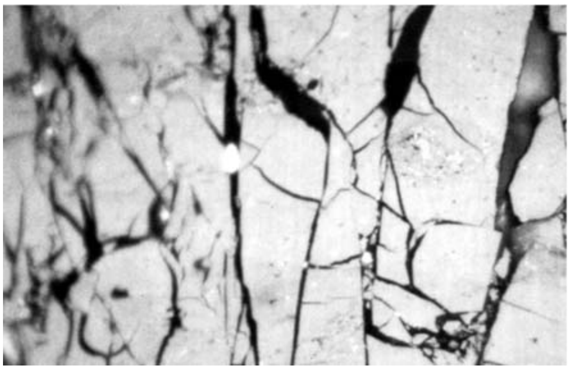

Figure 4. Vitrinite (grey) and exinite (black), Rvmax=0.65%, field width=0.28 mm. Seam C of Bojongmanik coals.

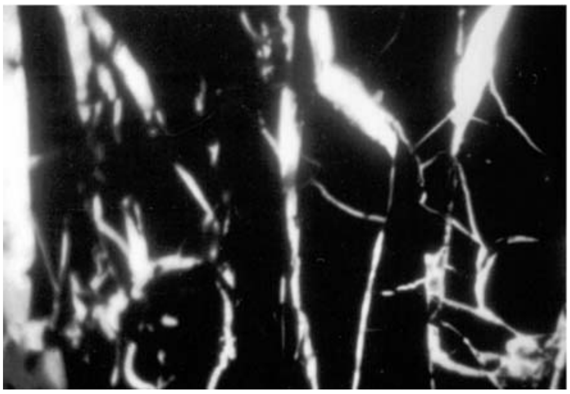

Figure 5. As for Figure 4, but in fluorescence mode

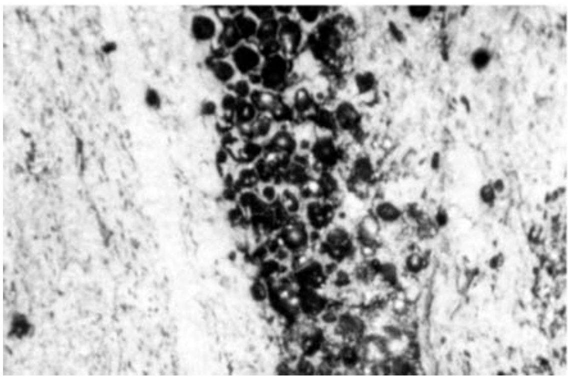

Figure 6. Resinite (black, rounded) associated with telovitrinite (grey), Rvmax=0.36%, field width=0.34 mm. Seam D of Cigudeg coals

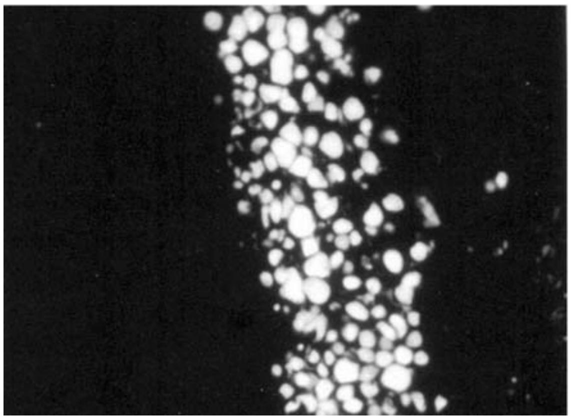

Figure 7. As for Figure 6, but in fluorescence mode.

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Mineral matter content is mostly high in both coals, extremely in seam B of the Bojongmanik coals that is 38.6% of pyrite and trace calcite.

Vitrinite reflectances of the Cigudeg and Bojongmanik coals vary from 0.24% to 0.39%. All the coals are ranked as brown coal according to the Australian classification or lignite to subbituminous B (ASTM). Based on the ASTM classification, the rank of the Bojongmanik coals is somewhat higher than that of the Cigudeg coals.

In summary, the vitrinite, inertinite and exinite contents of the Cigudeg and Bojongmanik coals are systematically related to one to another. The inertinite and exinite contents decrease with increases in vitrinite content.Ranks of the coals are relatively the same, which are brown coal (Australian classification) or lignite to subbituminous C-B (ASTM).

4.2. Discussion

The coal seams of the Bojongmanik Formation are found in the Cigudeg area (eastern part) and the Bojongmanik area (western part). The Cigudeg coals are associated with thin claystone and sandstone, whilst the Bojongmanik coals are associated with thick claystone, shale and sandstone. The coals were deposited in shallow neritic-brackish environment. The sea developed to the west due to the presence of thick limestone of the Bojongmanik Formation. To the east, its lithology is dominated by fluvial deposits. The Cigudeg coals have thicknesses of 0.2-0.4 m, whilst the Bojongmanik coals have thicknesses of 0.15-1.9 m. As shown in Tables 1 and 2, lithotypes of the Cigudeg coals (eastern part of the studied area) are duller than those of the Bojongmanik coals (western part). This indicates that the Cigudeg coals were formed under dry-swamp. Otherwise, the Bojongmanik coals were deposited in wet swamp due to marine intrusion into the swamp. This is supported by the presence of pyrite and calcite in the Bojongmanik coals rather than in the Cigudeg coals that are dominated by clay minerals and quartz.

Macerals of both coals are dominated by vitrinite over inertinite and exinite.This is indicative of forest type vegetation in humid tropical zone, without significant dry events throughout. Vitrinite-rich coals, particularly in the Bojongmanik coals, have high content of mineral matter present as discrete dirt bands, due to rapid subsidence (Cook, 1975; Shibaoka and Smyth, 1975).

Ranks of the coals range from lignite to subbituminous B in which the Bojongmanik coals are somewhat higher than the Cigudeg coals due to thicker overburden on the Bojongmanik coals. This is also supported by the calorific value of the Bojongmanik coals that are relatively higher than that of the Cigudeg coals (Santoso and Ningrum, 2003).

According to the type (vitrinite-rich, 49.2-86.6%) and rank (lignite-subbituminous B), the coals are in common suited for direct combustion.However, high moisture contents (18.3-26.3%, air-dried basis; Santoso and Ningrum, 2003) and spontaneous combustion will cause problems that generally occur in lower rank coal. The vitrinite-rich coals are suited for preparation in combustion, because they are easily ground through to the finer fraction. These coals are generally tougher than the more inertinite-rich coals. Resources of the coals in the studied areas are approximately 14 million tons (Hadiyanto, 2006). These resources are expected to cope with the coal demand in the areas. Some of the coals have been exploited and utilised by lime and brick combustion in the surrounding areas. The main utilisation will be for small-scale and home industries, which are available in the studied areas with strong demand of the coals.

5. CLOSING REMARKS

The Cigudeg and Bojongmanik coals of the Bojongmanik Formation were deposited under shallow neritic-brackish environment where marine developed from east to west. The coals are much thicker to the west, where the Cigudeg coals (east) are between 0.2 and 0.4 m, whilst the Bojongmanik coals (west) range from 0.15 to 1.9 m. This environment caused differences on lithotype, maceral and mineral composition. The Cigudeg coals are dominated by duller lithotypes (dull-banded, banded). On the contrary, the Bojongmanik coals are dominated by brighter lithotypes (bright). Inertinite contents are somewhat higher in the Cigudeg coals than those of the Bojongmanik coals. Pyrite is dominant in the Bojongmanik coals, whilst clay minerals and quartz are dominant in the Cigudeg coals.Ranks of the Bojongmanik coals are higher than those of the Cigudeg coals because of thicker overburden. Both coals are categorised as low-rank coals due to their low ranks as lignite to subbituminous C and their high moisture contents.

According to characteristics of both coals and urgent requirement demanded by the small-scale and home industries around the studied areas, the coals can be utilised as fuel of direct combustion. Besides their appropriate characteristics, resources of the coals can support its demand that can be used for relatively long time.

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