Characteristic of Coal Deposits in the East Kolaka, Southeast Sulawesi Province

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Abstract. Coal deposits in Southeast Sulawesi may not be large, one of the occurrence and deposit has been recorded in the Tawanga Village, East Kolaka Regency, Southeast Sulawesi Province. The study area is part of Southeast Arm of Sulawesi and the occurrence of coal is indicated from Meluhu Formation (TRm) which uncomformably overlying with schist of the Mekongga Complex (Pzm). In this study, field survey and proximate analysis of coal had been conducted to determine the distribution and quality of coal. Six coal samples from different area were subjected to the proximate analysis and the comparison of different properties including moisture content, volatile matter, fixed carbon, ash content and calorific values has been studied. The study is aimed to characterize of coal in the area through proximate analysis method. Field survey showed that the occurrence of coal as thin layers or lenses set in shale with thickness is vary from 5 to 20 cm. The analytical evaluation of properties showed the value of fixed carbon content 5.2 to 12.4%, the ash content 8.4 to 35.7%, the total moisture content 47.1 to 73.0% and volatile matter 7.0 to 10.7%. The analytical results suggest the existing of coal in the study area is classified as low rank calorie with the calorific value ranges between 1246.7 to 3644.6 cal/gr (adb).

Keywords: Coal, Proximate Analysis, Low Rank Calorie

1. Introduction

The occurrence of coal deposits in Sulawesi is not large. Directorate General of Mineral and Coal [1] reported the deposits of coal in the Sulawesi region came from South Sulawesi and Central Sulawesi with total resources at 231.12 and 1.98 million tons respectively. However, Southeast Sulawesi is also recorded the occurrences and deposits of coal. Surono [10] reported two coal seams have been found in Kendari city from Toronipa Member of the Meluhu Formation. The coal is characterized black, sheared due to the fault, abundant of pyrite, and rank of coal is between sub-bituminous and high volatile bituminous.

The coal deposits in Southeast Sulawesi are distributed in the Tawanga Village, East Kolaka Regency. This area is located in the eastern part of Kendari, a capital city of Southeast Sulawesi with geographic coordinates between $3^0$46’30” - $3^0$48’30” latitude and between $121^0$41’00” - $121^0$43’15”

longitude. Based on geological map of the Lasusua - Kendari Sheet, the study area is consisted of metamorphic rock of Mekongga Complex in age of Paleozoic and Alluvial deposits (Figure 1). This thing is different with another deposits of coal in others part of Sulawesi. In South Sulawesi, coal has been identified in the Eocene stratigraphic units of Malawa Formation and Toraja Formation while in the East Sulawesi, coal has been identified in the Triassic (Winto Formation) and Jurassic units (Nanaka Formation), as explained in Ref. [3].

Numerous previous studies had been conducted in this area. Ngkoimani et al [4] used petrography study to identification of coal in this area and resulted the rank of coal is lignite. In 2015, Ngkoimani et al [5] were back to study estimation of coal distribution in this area by using DC Resistivity Method and resulted that Tawanga area is potential for coal mining.

In this current study, it will be conducted field geological survey in the Tawanga Village to identification the distribution of coal and determine the characteristics and quality of coal by proximate analysis method.

2. Geological setting

Geologically, Sulawesi Island and its surrounding area are complex regions. The complexity was caused by convergence between three lithospheric plates: the nortward-moving Autralian Plate, the westward-moving Pacific Plate, and the south-southeast-moving Eurasian Plate [11]. Because of that, regional structures were developed especially in the Southeast Arm of Sulawesi (Figure 1) and its surrounding area.

The Southeast Sulawesi continental terrane which trends NW-SE is bounded by two major strike-slip fault systems. The northern-most fault is referred to as the Lawanopo Fault System, and the southern-most fault is named the Kolaka Fault [9]. The Lawanopo Fault System and Kolaka Fault are active sinistral faults [8]. Both of these faults are considered to extend from onshore the southeast arm of Sulawesi into Bone Bay. These faults are considered to have been active during the Plio-Pleistocene [8] according to cross-cutting relationships and deformation of sediments within Bone Bay.

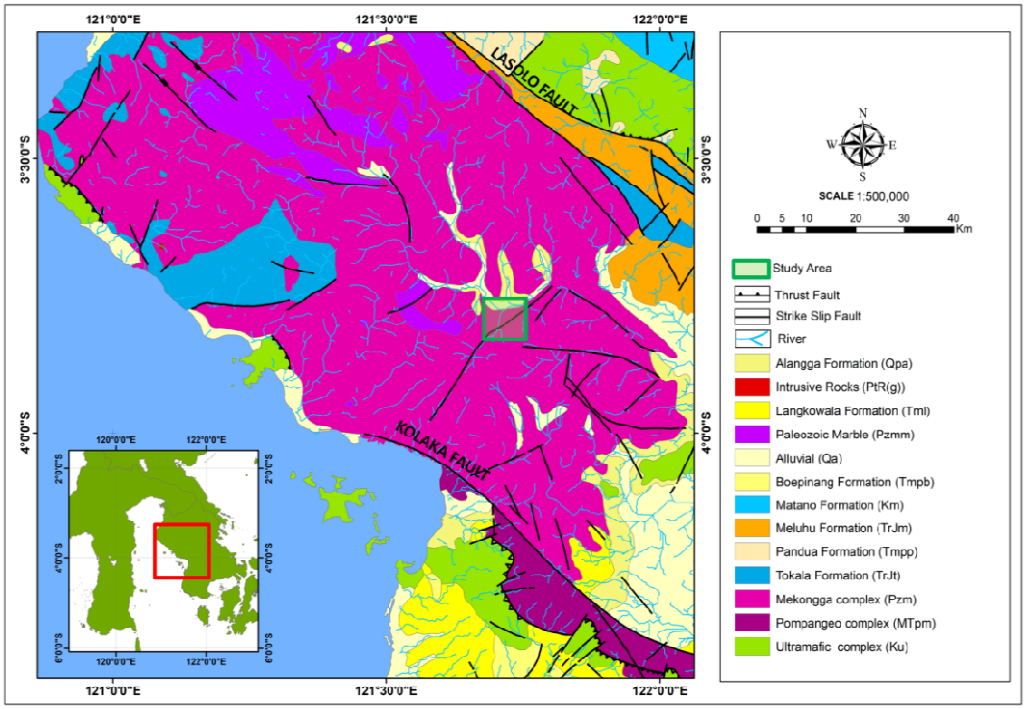

Figure 1. Geological map of the East Kolaka Regency, Southeast Sulawesi
(Part of the Geological Map of the Kolaka Sheet, scale 1:250.000, Simandjuntak et al, 1993 and Geological Map of the Lasusua-Kendari Quadrangles, scale 1:250.000, Rusmana et al, 1993)

Stratigraphy of the Southeast Arm of Sulawesi has detailed explained by Surono [8]. The oldest rocks in the Southeast Sulawesi continental terrane are metamorphic rocks which were intruded by granitic rocks. These are unconformably, overlain by clastic-dominated sediments of the Triassic Meluhu Formation, which is unconformably covered by a carbonate sequence of the Paleogene Tampakura Formation. Collision between the Southeast Sulawesi and Buton terranes occurred in the Latest Oligocene and developed the thrusts. The ophiolite which was located between these micro-continents, was thrust over the margins of the Southeast Sulawesi and Buton terrane during the collision. Thrusting was followed by uplift and erosion of the ophiolite and micro-continent with deposition in local fluvial basins which were part of the Early Miocene syn-orogenic clastic sediments of the Sulawesi Molasse. The Sulawesi Molasse is dominated by clastic units with local limestone. The clastic sequence consists of conglomerate of the Langkowala and Pandua Formations, sandy marl to claystone of the Boepinang Formation and sandstone with local coral reefs of the Buara Formation. After thrusting ended, collapse from block faulting caused trangression in the region and deposition of carbonate of the molasse.

3. Methodology

The methodology in this study by collected coal samples from six locations during field survey. Field sampling procedure was conducted both using chip and channel sampling methods. Most of coal samples were taken from Alaa Tawanga River and Palembua River which located in the Tawanga Village, East Kolaka Regency, Southeast Sulawesi Province.

Determination of coal quality was carried out by proximate analysis. All samples from six locations were taken and sent to Pusat Studi Pangan dan Gizi Universitas Gadja Mada. Proximate analysis is consisted of moisture value, ash value, volatile matter value, fixed carbon value, and calorie value.

4. Results

4.1. Field survey

Based on field survey, distribution of coal deposits are occurred in the Alaa Tawanga and Palembua Rivers. There are six stations were found of coal deposits (ST.6, ST.21, ST.22, ST.23, ST.24, and ST.25) and all are located in the river with fresh to weathered condition. Distribution of coal deposits in the study area relatively NE-SW to N-S. The occurrence of coal is mostly in thin layers or lenses set in shale with the thickness up to ±20 cm. The deposits are commonly associated with shale and sandstone. The contact between coal deposits with associated rocks are conformable.

The geological map of the study area (Figure 2) shows the major distribution is schist metamorphic rock of Mekongga Complex (Pzm) with distribution is very wide around 70% of the study area. While the remains distribution are coal and alluvial deposits (Qa). The distribution of coal is very minor or the smallest in the study and mostly as thin layers or lenses in shale and it can be observed in the northern and eastern parts of study area or near with the main river of Konaweha River.

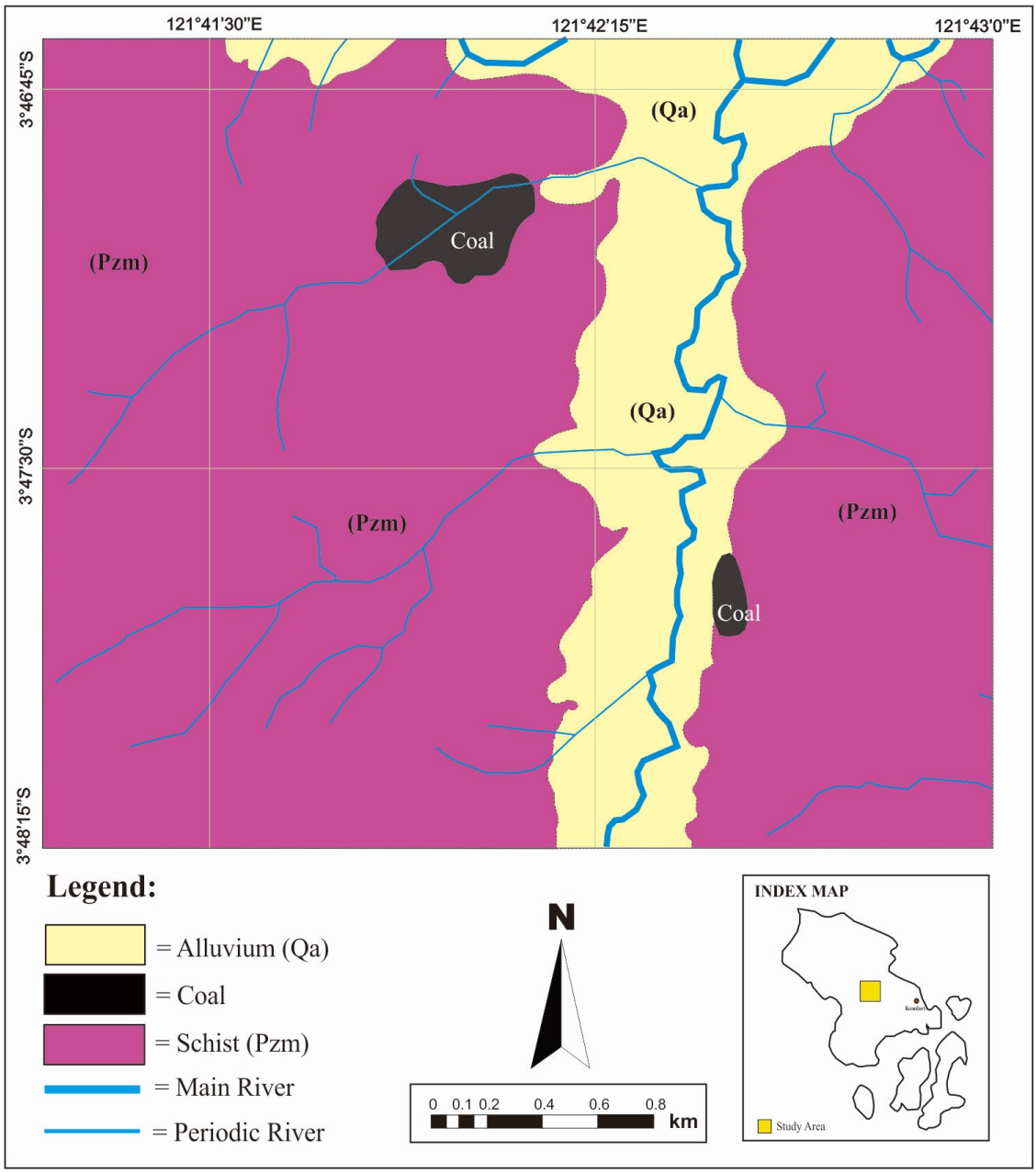

Figure 2. Geological map of the study area based on field survey.

Macroscopic appearance of coal (Table 1) in the Alaa Tawanga (ST.6) showed brownish to black, brittle, and laminated structure. The orientation of coal in this area relatively N-S with strike and dip value at N166°E/90°. The thickness of coal is from 6-13 cm. While coal exposure in the Palembua River (ST.21, ST.22, ST.23, ST.24, and ST.25) showed black, mostly weathered, very brittle, very wet, and coal deposits exhibited cleats or fractures. All strike and dip values show the orientation of coal in this area relatively NE-SW and its different with the orientation in the Alaa Tawanga River. A mass of plant debris is present in the rock texture. The thickness of coal is vary from 5 to 20 cm.

Table 1. The result of field survey for six stations of coal in the Tawanga Village

Station / Description	ST.6	ST.21	ST.22	ST.23	ST.24	ST. 25
Location	AT River	PB River	PB River	PB River	PB River	PB River
Strike/Dip	N166°E /90°	N240°E /27°	N232°E /42°	N232°E /42°	N220°E /74°	N256°E /45°
Colour	Bwn Black	Black	Black	Black	Black	Black
Luster	Dull	DMB	DMB	Dull	Dull	Dull
Streak	Brown	Black	Black	Black	Black	Black
Hardness	Brt	Vr Brt	Vr Brt	Vr Brt	Vr Brt	Vr Brt
Sorting	Poor	Poor	Poor	Poor	Poor	Poor
Impurities	-	PR	PR	PR	PR	PR
Structure	-	Cleat	Cleat	Cleat	-	-
Thickness	±6-13 cm	±18 cm	±20 cm	±13 cm	-	±5 cm

Explanation:

AT River = Alaa Tawanga River
PB River = Palembua River
Bwn Black = Brownish Black
DMB = Dull with Minor Bright
Brt = Brittle
Vr Brt = Very Brittle
PR = Plant Roots

Coal deposits in all stations showed the contact with sediments rock. The station six (ST.6) at the Alaa Tawanga River showed as thin layer of coal in shale. The coal observed with thickness is vary from 6-13 cm while shale observed with thickness up to 2.4 m. The uppert part of shale are overlain with sandstone and conglomerate with thickness is 80 cm and 1.5 m respectively with bedding pattern is coarsening upward (Figure 3A). At the bottom part of shale is also interbedded with sandstone and the thickness up to 2 m.

In the Palembua River (ST.21, ST.22, ST.23, ST.24, and ST.25), the occurrence of coal is showed by thin layers or lenses set in shale. The thickness of coal is vary from 5 to 20 cm (Figure 3B, 3C, 3D, 3E and 3F).

Figure 3. Photographs of the occurrence of coal observed in the Tawanga Village

4.2. Quality of coal

Coal proximate analysis is performed in Laboratorium Studi Pangan dan Gizi Universitas Gadja Mada to define ash content, moisture content, volatile matter, fixed carbon, and calorie value from coal samples from Tawanga Village, East Kolaka Regency, Southeast Sulawesi Province.

The result of proximate analysis from coal sample in six stations is showed on figure 4.

4.2.1. Ash content. Ash content is an impurity that will not burn. Ash will reduce burning capacity. Based on information, general coal properties of Indonesia for ash content is characterized by typical value at <10% as explained in Ref. [2], while ash contents range in the study area from 8.4 to 35.7% (Table 2). It is considered that ash contents in the study area are higher than normal value.

4.2.2. Moisture content. Moisture in coal must be transported, handled and stored. Since it replaces combustible matter, it decreases the heat content per kg of coal. General coal properties of Indonesia for moisture content is characterized by typical range is 10 to 45% as explained in Ref. [2], while moisture contents range in the study area between 47.1 to 73.5% (Table 2) and it is over of normal range value. This range indicate the typical of the low rank of coal with very high moisture.

4.2.3. Volatile matter. Volatile matter is an index of the gaseous (methane, hydrocarbons, hydrogen and carbon monoxide, and incombustible gases like carbon dioxide and nitrogen found in coal) fuels present. Proportionately, volatile matter increases flame length, and helps in easier ignition of coal. General coal properties of Indonesia for volatile matter is characterized by typical range is 25 to 45%

as explained in Ref. [2]. The volatile matter contents in the study area are relatively lower, ranging between 7 to 10.7% (Table 2). This range value indicates the typical of the low rank of coal.

4.2.4. Fixed carbon. Fixed carbon gives a rough estimate of heating value of coal. The increasing of fixed carbon content means the calorie value of coal will be higher. General coal properties of Indonesia for fixed carbon is characterized by typical range is 30 to 50% as explained in Ref. [2]. The Fixed carbon contents in the study area are relatively lower, ranging between 5.2 to 12.4% (Table 2). This range value indicates low calorie value.

4.2.5. Calorie value. Calorie value of coal samples in the study area are vary from the lowest value is 1246.7 cal/gr to the higher value is 3644.6 cal/gr (Table 2). According to the Goverment Regulation No.13/2000 and No. 45/2004, coal quality is classified into 4 type based on calorific value: 1) Low Calorie: <5100 cal/gr; 2) Medium Calorie: 5100-6100 cal/gr; 3) High Calorie: 6100-7100 cal/gr; and 4) Very High Calorie: >7100 cal/gr, as explained in Ref. [2]. Based on that classification, calorie values in the study area are classified into low rank calorie.

Table 2. The result of proximate analysis for six coal samples from Tawanga Village

Samples No.	Proximate Analysis (wt %)				CV (cal/gr)	Rank of Calorie
	AC	MC	VM	FC		
ST. 6	35.7	47.1	7.0	10.1	1246.7	Low Calorie
ST. 21	32.7	46.4	8.8	11.8	1816.6	Low Calorie
ST. 22	8.4	73.0	8.1	10.3	3644.6	Low Calorie
ST. 23	32.1	55.1	7.4	5.2	1876.9	Low Calorie
ST. 24	17.3	60.2	10.2	12.1	2833.8	Low Calorie
ST. 25	9.9	66.8	10.7	12.4	3190.4	Low Calorie
Mean:	22.7	58.1	8.7	10.3	2434.8	Low Calorie

Explanation:
AC : Ash Contents (wt %) FC : Fixed Carbon (wt %); CV : Calorie Value (cal/gr)
VM : Volatile Matter (wt %); MC : Moisture Contents (wt %);

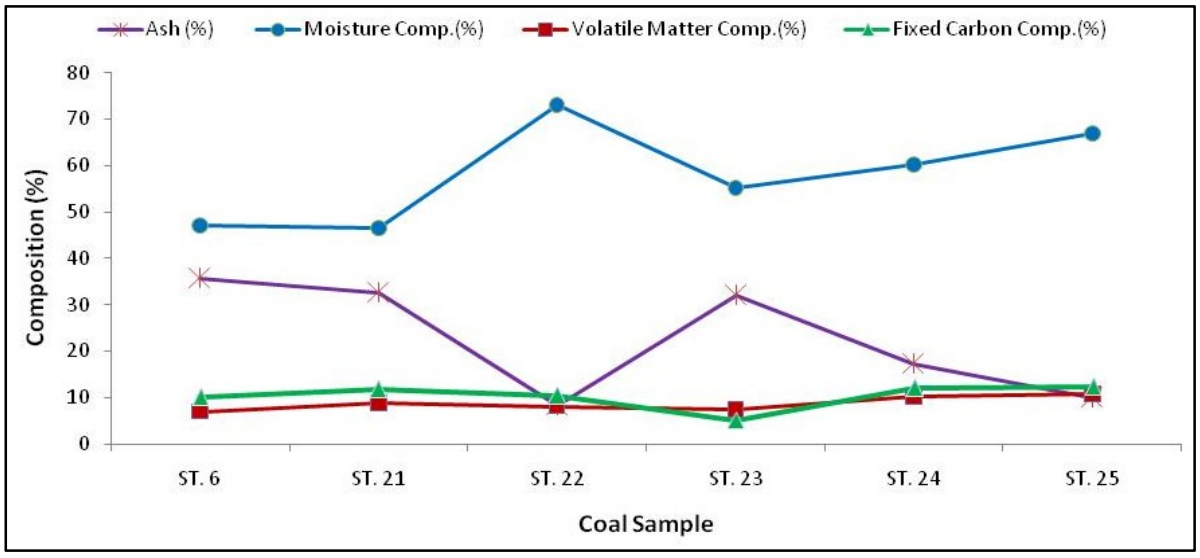

Figure 4. The result of proximate analysis from coal sample in six stations

5. Discussion

Based on field survey in the study area, typical of coal exposures display as thin layers or lenses set in shale. Shale in the study area showed interbedded with sandstone and conglomerate with sequence pattern is coarsening upward. Characteristic of the lithologies in study area can indicate that in the study area is developed of Meluhu Formation. This thing is based on identification of litology and texture of rocks which have similar with litology from Meluhu Formation. So, we postulate that the occurence of coal in the study area may be came from Meluhu Formation.

Proximate analysis is also showed that the value of ash content, moisture content, volatile matter and fixed carbon from six samples of coal indicates that typical of coal is tend to low rank of coal. This is also confirmed by calorie value which indicates the range of calorie is classified into low rank calorie. So, we indicate that typical coal in the study area is lignite coal with low rank calorie.

6. Conclusion

Based on field survey and proximate analysis of coal samples in the Tawanga Area, some conclusions can be drawn as follow:

1. Coal deposits in the study area are found in the six stations (ST.6, ST.21, ST.22, ST.23, ST.24, and ST.25). The coal display as thin layers or lenses set in shale with thickness is vary from 5 to 20 cm. The occurence of coal in study area may be carried by Meluhu Formation.
2. Based on proximate analysis, coal deposits in the study area is classified as low rank calorie with range between 1246.7 to 3644.6 cal/gr (adb).

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