Cleat properties of the Tanjung Agung coalfield, South Sumatra Basin: implications to fluid flow

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Abstract. Observation of the coal cleats of the Muara Enim Formation in Tanjung Agung coalfield aims to characterize the cleat properties and interpret their implications for fluid flow. This study used the scanline method to measure cleat attributes in the form of orientation, aperture, spacing, filler, and cleat connectivity. The face cleat was dominated by NE-SW direction as an indication of the effect of paleostress, while butt cleat with NW-SE direction indicated the effect of stress release. The presence of one major fault and three minor faults trending NW-SE in the mine pit is interpreted as the main controlling factor for cleat development in the study area. These cleats have an aperture ranging from 0.4 - 2.3 mm, good connectivity, and are not filled, so they are considered to be analogous to fluid flow paths with transition and turbulent flow types with relatively NE-SW direction.

1 Introduction

South Sumatra Basin is one of the most productive coal producing basins in Indonesia. The stratigraphic unit that acts as a coal-bearing formation in the South Sumatra Basin is the Muara Enim Formation which was deposited during the regression phase during the Late Miocene - Early Pliocene [1].

Tanjung Agung Coalfield is one of the coal mining areas of the Muara Enim Formation using the open pit method, so that there are many coal outcrops that can be observed for the purposes of various thematic studies (Figure 1). One of the interesting properties of coal to observe is the cleat because it can provide an overview of the characteristics of the cleat attribute and its ability to flow fluids, especially gas.

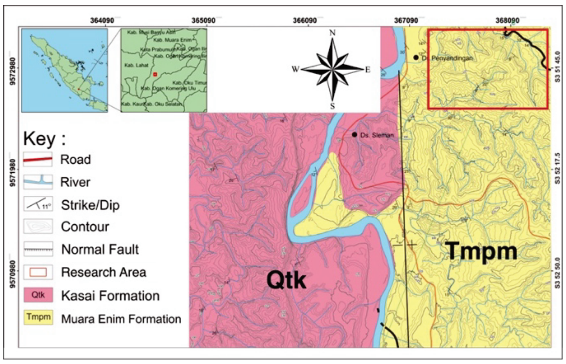

Fig. 1. The research area is in the Muara Enim Formation [2].

A number of previous studies stated that cleats can develop through many mechanisms in various periods of coal formation. These mechanisms include the dehydration, drying or devolatilization process during ripening which indicates a decrease in cleat space along with increasing coal rank [3]. The stress on coal from tectonic activity is also considered to have an effect on cleat formation because face cleats are considered to be extensional (opening-mode cleats), so its direction is often perpendicular to the direction of the minimum horizontal stress (minimum horizontal stress) and parallel to the direction of the maximum horizontal stress (maximum horizontal stress) [3]. Meanwhile butt cleats are interpreted to form during relaxation from the initial stress (Figure 2) [4]. Observation of cleats generally shows that the cleat is perpendicular to the direction of the thrust fault and fold hinge axes, so this phenomenon supports the hypothesis that cleats can be formed in response to tectonic activity.

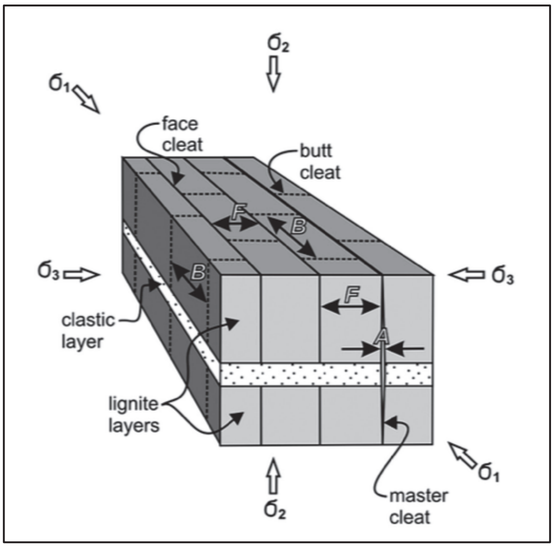

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Fig. 2. Illustration of cleat attributes and its relationship to stress [5].

Based on their formation, cleats are classified into endogenic and exogenic cleats. Endogenic cleats are cleats that are formed during the coal process due to dehydration, devolatilization, and matrix shrinkage. Meanwhile, exogenic cleats are generated from external forces such as tectonic activity. Apart from the endogenic processes mentioned above, cleat orientation shows the influence of tectonic stress [4-5]. Another classification is based on the relative cleat distance proposed dividing the cleats into three groups; macrocleat (measuring decimeter to centimeter), mesocleat (measuring millimeter), and microcleat (measuring micrometer) [5].

Observation of cleats on coal will be very useful in understanding coal permeability which can contribute to various engineering activities that utilize coal cleats. The coal permeability would be higher along the face cleat than along the butt cleat. Coal permeability through the cleat network is influenced by the cleat opening, space, orientation, height, and length. Coal permeability will generally increase with increasing cleat openings and decreasing cleat spacing which will have an impact on connectivity between cleats. Based on this interpretation, the cleat attributes that need to be investigated in the context of understanding fluid flow in coal are space, length, height, connectivity, aperture, level and type of mineral filling, and orientation.

This study uses low rank coal in the Muara Enim Formation of the South Sumatra Basin as the object of research. The coal is exposed in the mining area, so fresh coal can be found along the outcrop. The coal is unformally divided into four parts (B1, B2, B3, and B4) which are exposed in the mine openings of a company in Tanjung Agung District, Muara Enim Regency, South Sumatra (Figure 3). The selection was based on the potential for CBM resources in the South Sumatra Basin which reached 183 TCF (equivalent to 41% of the total CBM resources in Indonesia), so it is necessary to carry out detailed observations of the coal cleats of the Muara Enim Formation in various areas for activities [6]. CBM exploration-production as well as other geological extraction activities in the Muara Enim Formation coal which utilizes coal cleats.

Fig. 3. Coal outcrop of the Muara Enim Formation in Tanjung Agung coalfield.

2 Methods and data

This study used a descriptive-observative approach with data sources obtained from field observations. Cleat data acquisition uses the scanline method along the coal seam. The scanline method is used to anticipate duplication of cleat data measurements and validate face and butt cleat data collected from the field prior to further analysis [7].

The object of this research is the measurement results of cleat attributes which include orientation, aperture, spacing, filler, and cleat connectivity using a measuring tape, calipers, and a geological compass. Meanwhile, cleat length and height are not measured because it cannot be measured completely in the coal outcrop. Cleat measurement using the scanline method in one of the mining areas in Tanjung Agung produces 400 cleat data (Table 1 and Table 2).

Table 1. Measurements results of face cleat attributes.

Seam	Face Cleat			
	Orientation (N…°E)	Aperture (mm)	Spacing (cm)	Freq
B1	213-226	0.6-1.15	1.72-2.74	50
B2	197-223	0.6-0.9	1.42-2.83	50
B3	194-219	0.5-1.7	0.56-2.93	50
B4	193-206	0.45-2.3	0.65-2.74	50

Table 2. Measurements results of butt cleat attributes.

Seam	Butt Cleat			
	Orientation (N…°E)	Aperture (mm)	Spacing (cm)	Freq
B1	294-314	0.4-0.65	1.66-2.63	50
B2	278-313	0.45-0.85	1.52-2.86	50
B3	278-216	0.4-0.85	1.27-2.86	50
B4	283-304	0.4-0.75	1.295-1.9	50

The measurement results will be variables in the data analysis to determine the cleat property and its implications for gas flow. The cleat property is correlated with the classification of flow types based on their geometry and connectivity. The analysis is also accompanied by stereographic analysis to match the direction of regional forces acting around the study area, so that the genesis of the cleat formation can be interpreted.

3 Result and discussion

The coal in the study area has a total thickness of 12.8 meters with the characteristic of being dominated by banded dull coal lithotype, tuff parting, and the position of the layer is N114°E/14°. The developed face cleat is generally in a NE-SW direction, while the butt cleat is in a NW-SE direction. The general orientation of the face cleat has the same relative direction with the orientation of the fault structure around the mine pit (Figure 4).

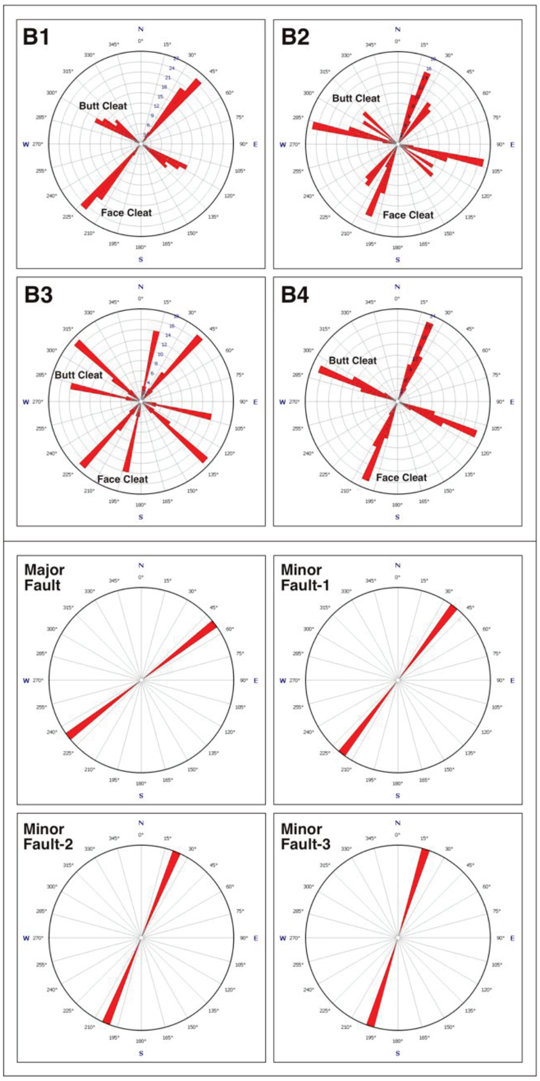

Fig. 4. The orientation similarities between face cleats and fault structures in the mine pit.

The formation of cleats in coal has started to occur by many mechanisms in various periods of coal, but the presence of one mayor fault and three minor faults trending NE-SW in the mine pit are interpreted as the main controlling factor for cleat development in the study area (Figure 5). This interpretation occurs with about cases found in cleats in Tanjung Enim Coalfield which have cleat face orientation conditions and patterns that show relative directions in Quadran III [8].

Fig. 5. Minor faults in the mine pit (blue bag as parameter).

Cleat aperture ranges from 0.4 - 2.3 mm, good connectivity, and not filled. The aperture range of the cleats is included as a macroscopic fracture in the gas flow pattern model in the fracture-pore system with the transitional flow and turbulent flow types [8]. The cleat condition is considered to be analogous to a good fluid flow path with an estimated NE-SW relative flow direction (Figure 6).

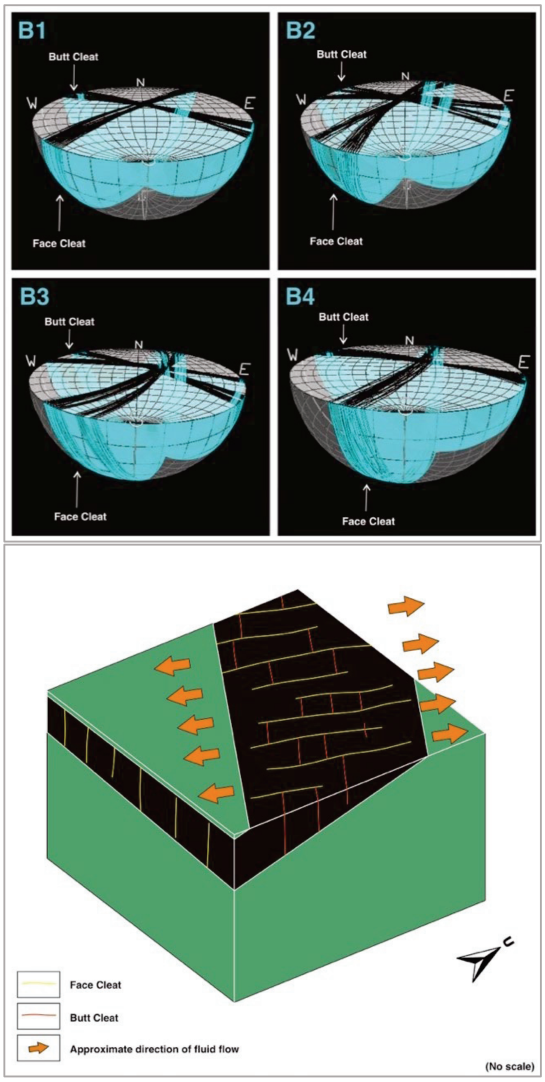

Fig. 6. 3D cleat stereographic analysis and illustration of the approximate direction of fluid flow.

4 Conclusion

The coal in the study area has cleat properties that are influenced by tectonic activity so that it has an orientation that is in the same direction NE-SW as the faults in the pit and a qualified aperture as a fluid flow path with good connectivity between cleats. The cleat property is very important as an analogue of the direction of exploration and production of various fluids in the coal and as a reference for the type of treatment of coal in engineering activities related to the coal cleats of the Muara Enim Formation in Tanjung Agung District, Muara Enim Regency, South Sumatra.

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