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Analysis of Coal Seam Identification Based on Drilling Data in Nunukan Regency, North Kalimantan

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ABSTRACTS

Coal deposition results in the formation of continuous layers with specific thicknesses and slopes. This study aimed to determine coal seams based on drilling data. The method involved correlating the rocks flanking the coal seams using AutoCAD 2014 software. The findings revealed that points BC-054, BC-045, and BC-038 belong to the same coal seam based on the associated flanking rocks. Similarly, points BC-029, BC-022, BC-004, and BC-087 were also found to be interconnected within a coal seam, sharing similar thicknesses and clamping rock layers. However, the third layer at BC-087 does not correspond with other boreholes and is categorized as a separate seam. Correlation analysis identified three coal seams with an average thickness ranging from 0.6 m to 1.7 m.

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INTRODUCTION

Indonesia is among the world's largest coal-producing nations, with Kalimantan being the leading contributor to its production. Coal serves as a vital energy source for both domestic consumption and export. Nunukan, situated in North Kalimantan, possesses substantial coal resource potential, although it remains underutilized (Juradi et al., 2021). Identifying coal seams through drilling data is a crucial step in mining exploration and development, ensuring a mining site's economic and technical viability (Thomas, 2012). Coal forms through accumulated vegetation over millions of years, undergoing decay, compression, and deposition processes. These processes are influenced by various chemical and physical factors, including temperature, pressure, humidity, and oxidation (Shabiruddin et al., 2022).

Identifying coal seams through drilling data has been a key focus of numerous studies due to its critical role in mining exploration (Bakri et al., 2022). For example, Ahmad et al. (2015) demonstrated that integrating drilling and geophysical data yields more accurate results in determining coal seam thickness and distribution. Their study in South Kalimantan produced detailed coal seam maps that greatly enhanced mining planning. Similarly, Rahman et al. (2018) emphasized the value of modern technologies, such as geostatistical modelling, in coal seam analysis. Their research in South Sumatra showed that geostatistical modelling could address the limitations of uneven drilling data, providing more reliable estimates of coal seam distribution. Despite these advancements, most studies have focused on regions with well-established coal mining activities, such as East Kalimantan, South Kalimantan, and South Sumatra (Anshariah et al., 2022; Liu, 2020). In contrast, the Nunukan region in North Kalimantan, which holds significant coal resource potential, remains underexplored. For instance, the Indonesian Geological Agency (2021) highlighted the coal potential in North Kalimantan but identified a lack of detailed coal seam mapping using the latest drilling data.

Research on coal seam analysis in Nunukan, North Kalimantan, remains limited, with most previous studies neglecting the region's unique geological characteristics that significantly influence coal seam distribution. Additionally, drilling data analysis methods in this area have yet to fully adopt modern technologies or integrated approaches, such as geostatistical modeling. This study introduces a novel approach to coal seam determination, focusing specifically on the Nunukan region. By

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integrating detailed drilling data analysis with advanced geological modeling techniques, it aims to generate more accurate coal seam distribution maps. The research also seeks to contribute to the comprehensive mapping of energy resources in Indonesia's border regions. The primary objectives of this study are to identify coal seams from drilling results, estimate the number of seams within Block C, and determine the average thickness of each coal seam layer.

METHODS

The research methodology involves direct field data collection, primarily through the role of a wellsite geologist to monitor all drilling activities at the study site (Jafar et al., 2022). This includes recording lithological changes, describing the physical characteristics of drilling cuttings, and capturing the coordinate points of each drilling location (Suwarna et al., 2006; Zetra et al., 2018). Data processing and analysis were conducted using Microsoft Excel, LogPlot, and Software X (Setiawan Bambang, 2009; Zamani et al., 2023). The outcome of this process is the correlation of coal seams across various drilling points. The stages of data processing and analysis include the following:

- Input the drilling observation data into the 2003 LogPlot application, including:
  (a) borehole name, drilling date, and time;
  (b) XYZ coordinates;
  (c) names of the wellsite geologist, driller on duty, and geologist;
  (d) lithology columns, including thickness and physical descriptions of the rocks; and
  (e) depth and thickness of coal.
- Data related to drilling activities, including encountered problems, solutions implemented, fuel consumption, and equipment malfunctions.
- Create a cross-section between boreholes using AutoCAD 2014 software by following these steps:
  (a) Input the coordinates of Block C within the company's IUP area,
  (b) Enter the coordinate data for 28 drill points,
  (c) Develop a 2D cross-section in the north-south direction, creating four sections based on the 4 x 7 drill point grid model,
  (d) Set appropriate horizontal and vertical scales,
  (e) Manually construct a lithology column for each borehole depth, and
  (f) Plot additional drill holes according to the spacing in the drill point distribution, then input lithology data for all drill holes.

Correlate the coal layers between boreholes in the cross-section by matching the upper and lower bounding rock similarities (Anggayana et al., 2014; Li, 2022).

RESULTS AND DISCUSSION

Observations of drilling activities in Block C of the research area yielded the data for each drill point, as presented in Table 1.

Table 1. Drilling observations

No	Drill Hole		Total Depth (m)	From (m)	To (m)	m
1	BC-001	18.00	80.00	15.45	18.10	2.65
				47.60	47.90	0.30
2	BC-002	28.00	60.00	49.30	52.90	3.60
3	BC-003	25.00	60.00	28.25	29.25	1.00
4	BC-004	14.00	60.00	24.20	24.40	0.20
5	BC-084	26.00	45.00	16.30	16.67	0.37
				21.90	22.28	0.38
				30.90	31.00	0.10

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6	BC-085	26.00	64.50	44.85	47.60	2.75
				60.00	60.40	0.40
7	BC-086	25.00	90.00	21.40	21.60	0.20
				32.45	33.85	1.40
				74.20	75.00	0.80
8	BC-087	34.00	81.00	35.70	36.00	0.30
				50.40	53.10	2.70
				67.00	68.30	1.30
9	BC-024	33.00	60.00	35.25	35.93	0.68
10	BC-023	19.00	72.00	25.15	27.75	2.60
				48.60	50.10	1.50
11	BC-022	31.00	60.00	19.65	20.95	1.30
12	BC-029	17.00	67.00	24.65	25.85	1.20
13	BC-028	18.00	60.00	28.75	29.90	1.15
14	BC-027	32.00	24.00	NO COAL		
15	BC-040	35.00	45.00	NO COAL		
16	BC-039	32.00	75.00	22.30	22.40	0.10
				61.80	63.35	1.55
				67.70	70.85	3.15
17	BC-038	70.00	75.00	23.80	24.40	0.60
18	BC-045	15.00	75.00	34.10	34.90	0.80
19	BC-044	24.00	75.00	26.20	26.50	0.30
				33.00	33.30	0.30
20	BC-043B (Redrill)	52.00	37.50	NO COAL		
21	BC-025	15.00	90.00	45.30	45.94	0.64
				46.40	48.00	1.60
				48.20	49.50	1.30
				67.50	68.50	1.00
22	BC-026	19.00	70.00	49.70	52.50	2.80
				57.70	58.30	0.60
23	BC-041	18.00	70.00	41.40	43.10	1.70
24		30.00	60.00	47.80	49.50	1.70
25	BC-056	23.00	60.00	NO COAL		
26	BC-055	32.00	70.50	42.00	45.30	3.30
				64.00	65.00	1.00
27	BC-054	47.00	61.50	23.35	26.15	2.80
28	BC-057	11.00	60.00	45.00	46.80	1.80

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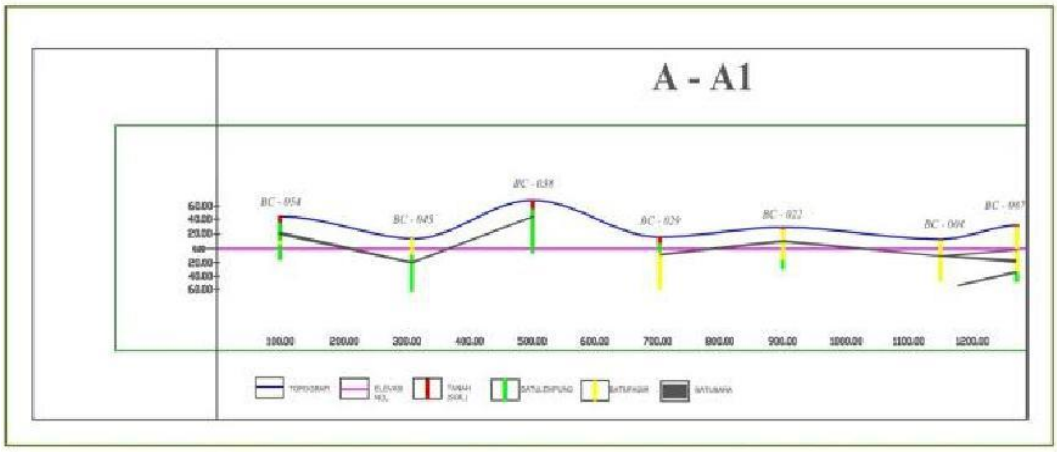

Figure 1 Cross-section of A-A1 from North to South

Figure 1 illustrates the cross-section comprising drill points BC-054, BC-045, BC-038, BC-029, BC-022, BC-004, and BC-087. The spacing between points is approximately 200 m, except for BC-004 and BC-087, which are only 100 m apart. Based on lithological similarities, the interpretation of cross-section A-A1 identifies three distinct coal seams:

- Drill points BC-054, BC-045, and BC-038 belong to the same coal seam, where the layer follows the elevation of the drill points. The average thickness of this seam is calculated as (2.80 m + 0.80 m + 0.60 m) / 3 = 1.4 m.
- Drill points BC-029, BC-022, BC-004, and BC-087 share a coal seam with nearly identical thicknesses. However, there is branching between the coal seams of BC-004 and the first and second layers of BC-087, supported by the presence of similar clamping rocks. The average thickness of this seam is (1.20 m + 1.30 m + 1.00 m + 2.70 m) / 4 = 1.55 m.
- The third layer of BC-087 does not correlate with the coal seams in the other boreholes, suggesting it represents a distinct seam.

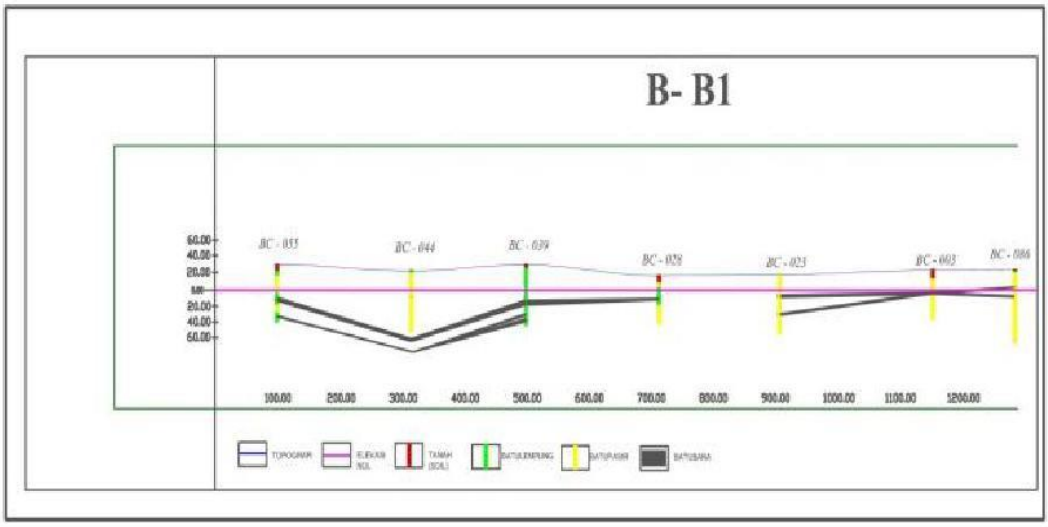

Figure 2. Cross-section of B-B1 from North to South

In Figure 2, the drill points are arranged from north to south: BC-055, BC-044, BC-039, BC-028, BC-023, BC-003, and BC-086. The spacing between points is approximately 200 m, except between BC-003 and BC-086, where the distance is only 100 m. Upon further analysis, it is interpreted that this cross-section contains two coal seams. No coal layers were identified at BC-055 and BC-044. Coal was first encountered at BC-039, where the lithology matches that of BC-055, consisting of two

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coal layers. Additionally, the third layer at BC-039 is believed to have branched off from the second layer at BC-055.

Based on these observations, it is assumed that the coal seam folds downward beyond drill point BC-044. The coal seam correlation is disrupted between BC-028 and BC-023 due to significant lithological differences. Additionally, in subsequent layers, two coal seams exhibit branching within the first and second layers of BC-086. The second layer at BC-023 correlates with the third layer at BC-086, extending through BC-003 without cutting the rock layers, as the drilling depth at BC-003 does not reach the second coal layer. An anomaly is observed between BC-028 and BC-023, where no lithological similarity is found in the flanking rocks of either the first or second layers. Despite this, the elevations of these two points are nearly identical and almost perpendicular. To ensure continuity and improve the resolution of this layer, it is recommended to conduct additional drilling with closer spacing between these two points.

The average thickness of each coal seam based on lithological correlation is as follows:

- The correlation results of the BC-055, BC-044, BC-039, and BC-028 points are 3.30m + 0.30m + 5.15m + 1.15m = 9.9m / 4 = 2.49m. The correlation results of the BC-023, BC-003, BC-086 points are 2.60m + 1m + 1.40 m = 5m / 3 = 1.667m.
- For the results of the correlation of the second layer of each point of BC-055, BC-044, and BC-039 are 1m + 0.30m + 1.55m = 2.85m / 3 = 0.95m. For the correlation results of the second coal seam at the point of BC-023, and BC-086 is 2.60m + 0.80m = 3.40 / 2 = 1.7m.

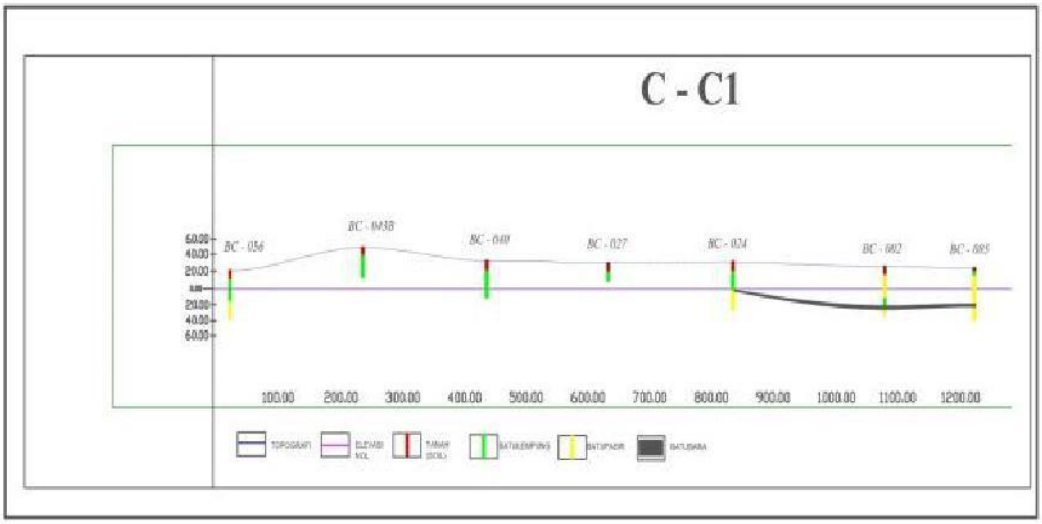

Figure 3. Cross-section of C-C1 in the direction of North to South

The cross-section in Figure 3 includes drill points BC-056, BC-043B, BC-040, BC-027, BC-024, BC-002, and BC-085. The distance between most points is approximately 200 m, except for the distance between BC-002 and BC-085, which is around 100 m. In this C-C1 cross-section, four points lack coal seams due to their shallow borehole depths, ranging from 27 m to 45 m, which are insufficient to reach the coal seam found at the deeper points. The absence of coal seam data at these four points limits the diversity of the seam data.

Points BC-024, BC-002, and BC-085 share the same coal seam with identical lithology, and no branching of coal seams is observed in this cross-section.

The average thickness of each coal seam based on the lithological correlation results is as follows:

- The results of the correlation of points BC-024, BC-002 and BC-085 is 0.68m + 3.60m + 0.40m = 4.68m / 3 = 1.56m.
- The correlation results of the BC-023, BC-003, BC-086 points are 2.60m + 1m + 1.40 m = 5m / 3 = 1.667m.

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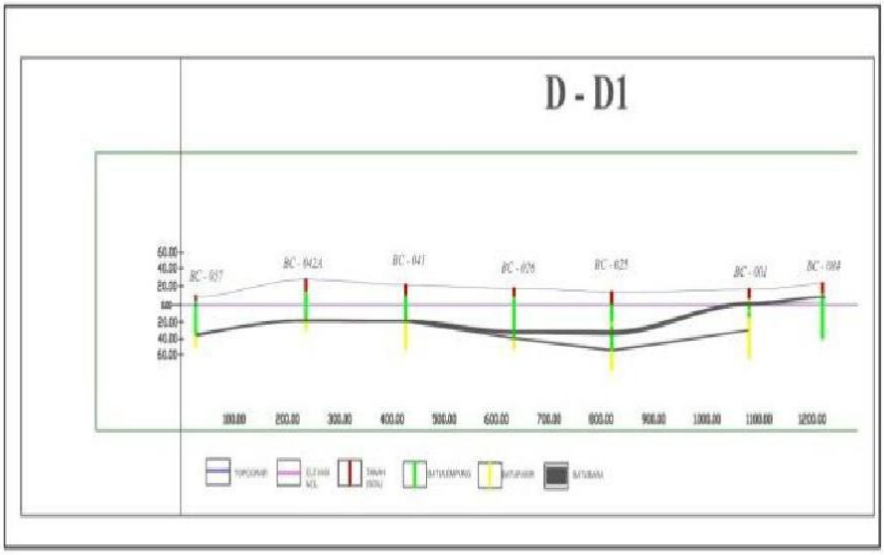

Figure 4 Cross-section of D-D1 from North to South

The fourth section in Figure 4 includes drill points arranged from north to south as follows: BC-057, BC-042A, BC-041, BC-026, BC-025, BC-001, and BC-084. The distance between most points is approximately 200 m, except between BC-001 and BC-084, where the distance is around 100 m.
The correlation results from this cross-section indicate the presence of a single coal seam, which branches in the second layer at the BC-026 point. This branching continues into the second layer of BC-025 and ends in the second layer of BC-001. It is estimated that the branching coal seam thins as it extends southward.
The average thickness of the coal seam in this cross-section is as follows:

- For the correlation of the drill point BC-057, BC-042A, BC-041, BC-026, BC-025, BC-001, and BC-084 i.e. 1.80m + 1.70m + 1.70m + 2.80m + 3.54m + 2.65m + 0.37m = 14.65m / 7 = 2.08m,
- For the layer resulting from the branching of the previous layer at the point BC-026, BC-025, BC-001, which is 0.60m + 1m + 0.30m = 1.90m / 3 = 0.633m.

CONCLUSION

Based on the results of observations and analysis of the coal seam, it can be concluded that the determination of seams, relying on rock clamping (lithocorrelation), is less accurate when based on borehole data from the open hole and touch coring methods, due to numerous inconsistencies in the clamping rocks. The relatively large distance between boreholes, ranging from 120 to 200 m, further complicates the interpretation of the coal seam, making the results less convincing. The coal seams in Block C, as identified through drilling, are assumed to consist of three seams, based on lithological correlation results. The average thickness of the coal seams in Block B, based on drilling data, ranges from 0.63 m to 1.7 m, classifying them as thin coal seams.

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