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# GEOLOGY AND COAL DISTRIBUTION PATTERNS OF THE SINAMAR FORMATION AT JUJUHAN SUBDISTRICT, BUNGO REGENCY

# *GEOLOGI DAN POLA SEBARAN BATUBARA FORMASI SINAMAR DI KECAMATAN JUJUHAN, KABUPATEN BUNGO*

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**Abstract.** Coal is a vital energy resource for Indonesia, particularly within the Jambi Province. Several coal bearing formations in the region, such as the Muara Enim and Sinamar Formations, are known to host high-quality coal. Despite this potential, geological research on the Sinamar Formation remains limited compared to the Muara Enim Formation. This study is located within the Mining Business License area of PT Kuansing Inti Makmur, specifically in Tanjung Belit Village, Jujuhan District, Bungo Regency, Jambi Province. The objective of this research is to characterize the geological conditions and coal distribution patterns to support future mine planning. The methodology includes field observations through geological mapping, rock sampling, and petrographic analysis, complemented by indirect observations via subsurface modeling using Minescape software based on company borehole data. The results indicate that the morphology of the study area consists of Structural Hills (S1) and anthropogenic landforms, including Mine Excavation Unit (A1) and Waste Dump Unit (A2). Stratigraphically, the area is composed of the Sinamar Conglomerate Unit with andesite fragments, the Sinamar Sandstone Unit, and the Sinamar Claystone Unit. A Left Normal Slip Fault with a general northwest–southeast orientation was identified. The coal distribution pattern consists of three seams (Seams A, B, and C) with thicknesses ranging from 1.5 to 6 meters. In conclusion, the coal layers in this area exhibit a strike of N 293° E – N 305° E with an average dip of 23°–30°.

***Abstrak.*** *Batubara merupakan sumber daya energi yang vital bagi Indonesia, khususnya di Provinsi Jambi. Beberapa formasi pembawa batubara di wilayah ini, seperti Formasi Muara Enim dan Formasi*

*Sinamar, diketahui mengandung batubara berkualitas tinggi. Terlepas dari potensi tersebut, penelitian geologi mengenai Formasi Sinamar masih terbatas dibandingkan dengan Formasi Muara Enim. Penelitian ini berlokasi di wilayah Izin Usaha Pertambangan (IUP) PT Kuansing Inti Makmur, tepatnya di Desa Tanjung Belit, Kecamatan Jujuhan, Kabupaten Bungo, Provinsi Jambi. Tujuan penelitian ini adalah untuk mengkarakterisasi kondisi geologi dan pola sebaran batubara guna mendukung perencanaan tambang di masa depan. Metodologi penelitian mencakup pengamatan lapangan melalui pemetaan geologi, pengambilan sampel batuan, dan analisis petrografi, yang dilengkapi dengan pengamatan tidak langsung melalui pemodelan bawah permukaan menggunakan perangkat lunak Minescape berdasarkan data lubang bor perusahaan. Hasil penelitian menunjukkan bahwa morfologi daerah penelitian terdiri atas Perbukitan Struktural (S1) dan bentuk lahan antropogenik, yang meliputi Unit Galian Tambang (A1) dan Unit Timbunan Material Buangan (A2). Secara stratigrafis, daerah ini tersusun oleh Unit Konglomerat Sinamar dengan fragmen andesit, Unit Batupasir Sinamar, dan Unit Batulempung Sinamar. Teridentifikasi adanya sesar normal geser kiri (left normal slip fault) dengan orientasi umum barat laut–tenggara. Pola sebaran batubara terdiri atas tiga lapisan (Lapisan A, B, dan C) dengan ketebalan berkisar antara 1,5 hingga 6 meter. Sebagai kesimpulan, lapisan batubara di daerah ini memiliki arah jurus (strike) N 293° E – N 305° E dengan kemiringan (*dip*) rata-rata 23°–30°.*



## 1. INTRODUCTION

Coal plays a dominant role in Indonesia's national energy mix, contributing significantly to electricity generation and economic development (Pahlevi et al., 2024; Sutrisno et al., 2021). Jambi Province is one of the major coal-producing regions on Sumatra, with estimated coal reserves of approximately 913.868 million tonnes (Yasin et al., 2021). Most of the province lies within the South Sumatra Basin, where the coal-bearing Muara Enim Formation is extensively developed (Simandjuntak et al., 1994; Mangga et al., 1993). Consequently, numerous geological studies on the Muara Enim Formation have been published over the past decade, including studies by Zahar et al. (2022), Rumbewas et al. (2021), Anwar et al. (2021), Ananto et al. (2023), and Ogara et al. (2025).

However, coal resources in Jambi Province are not confined to the Muara Enim Formation. Another important coal-bearing unit is the Sinamar Formation, which is exposed in several parts of Bungo Regency, particularly in Jujuhan Subdistrict. Despite its economic significance, geological research on the Sinamar Formation in Jambi Province remains limited. Previous studies have mainly focused on specific aspects of the formation, such as the petroleum potential of Sinamar shale in Tanah Tumbuh Subdistrict (Tobing, 2016) and coal quality through proximate analysis in Rantau Pandan Subdistrict (Nur et al., 2020). To date, no published study has comprehensively integrated geomorphology, stratigraphy, structural geology, petrographic analysis, and subsurface coal seam continuity within the Sinamar Formation, particularly in Tanjung Belit Village, Jujuhan Subdistrict. Moreover, no study has presented a three-dimensional interpretation of coal seam continuity based on drilling data, despite its importance for coal resource evaluation and mine planning.

The present study was conducted within the Mining Business License area of PT Kuansing Inti Makmur, which covers approximately 2,896 ha in Jujuhan Subdistrict (Sugianto et al., 2020). Geological mapping was carried out to characterize the geomorphology, stratigraphy, lithology, and geological structures of the study area, providing the surface geological framework for subsurface interpretation (Utama, 2023).

To complement these observations, coring data were utilized to analyze the spatial distribution and continuity of coal seams, enabling a more comprehensive understanding of the subsurface geology (Liu et al., 2023).

Therefore, this study aims to characterize the surface geology, analyze the subsurface distribution and continuity of coal seams using coring data and reconstruct the depositional environment of the coal-bearing succession in the study area. By integrating detailed geological mapping with subsurface modeling, this study provides a comprehensive geological interpretation of the Sinamar Formation in Jujuhan Subdistrict and contributes valuable information for coal resource evaluation and future mine planning at PT Kuansing Inti Makmur.

## 2. LITERATURE REVIEW

The study area, which is underlain by the Sinamar Formation, is located within the Mining Business Licence area of PT Kuansing Inti Makmur, Tanjung Belit Village, Jujuhan Subdistrict, Bungo Regency, Jambi Province (**Figure 1**). According to the Painan Geological Map, the Sinamar Formation consists of conglomerate, coarse-grained quartz sandstone, mica-bearing quartz sandstone, arkosic sandstone, marly claystone, sandy claystone, coal, and coral limestone (Rosidi et al., 1996). Geological cross-sections presented on the Painan Geological Map indicate that the Oligocene Sinamar Formation unconformably overlies the Permian basement rocks, referred to by Rosidi et al. (1996) as the Barisan Formation, which comprises phyllite, slate, limestone, hornfels, and metagreywacke. In addition to its unconformable contact with the Barisan Formation, the Sinamar Formation also unconformably overlies Jurassic granite and is, in turn, unconformably overlain by the Pliocene–Pleistocene Kasai Formation.

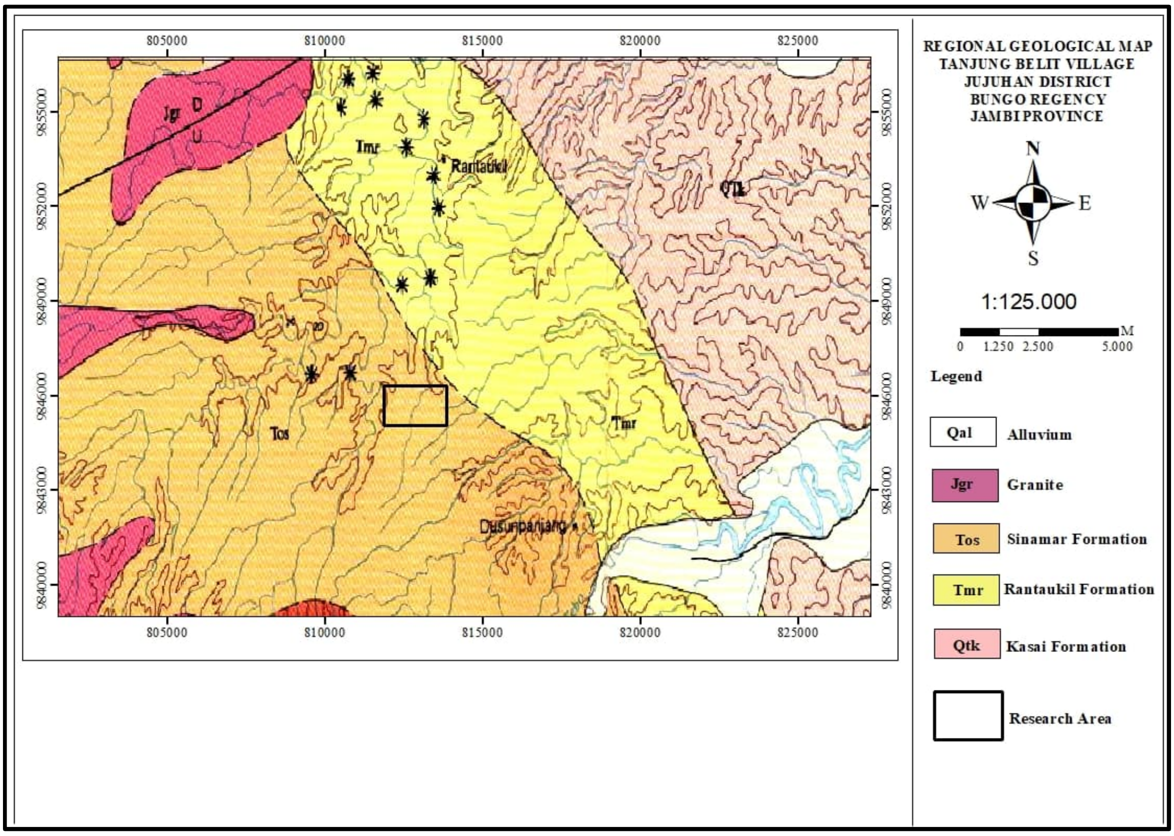


**Figure 1.** Regional geological map of the study area, modified from Rosidi et al. (1996; original scale 1:250,000) by adding the study area boundary, coordinate grid, legend, and map layout. The map is displayed at 1:125,000 using the UTM Zone 48S coordinate system.

Physiographically, the study area is situated on the eastern limb of the Barisan Range anticline, between the South Sumatra Basin and the Ombilin Basin. The Sinamar Formation extends into Dharmasraya Regency, West Sumatra, where Satriawan et al. (2025) investigated its coal quality and coal resources. The regional geological structure is dominated by northwest–southeast-trending normal faults (De Coster, 1974, cited in Zajuli, 2014).

Based on the literature review of Rosidi et al. (1996), the Sinamar Formation is composed predominantly of conglomerate, sandstone, claystone, and coal. Conglomerate, sandstone, and claystone represent clastic sedimentary rocks, whereas coal is an organic sedimentary rock formed through the accumulation and coalification of plant material (Maulana et al., 2020).

Coal seams exhibit various subsurface geometries controlled by depositional and post-depositional processes, including parting, splitting, washout, folding, and faulting (Simatupang et al., 2024). Parting refers to the separation of a coal seam by thin clastic sediment layers, commonly carbonaceous claystone. Splitting occurs when sedimentary material divides a coal seam into two or more separate seams (**Figure 2**), whereas washout refers to the erosion and subsequent replacement of part of a coal seam by younger sedimentary deposits (**Figure 3**).

Folding and faulting are common structural features affecting coal seams. Folding involves the bending of coal seams, whereas faulting results in their fracture and displacement (**Figure 4**).

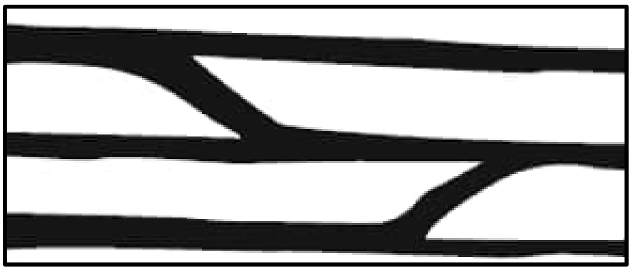

**Figure 2.** Splitting of a coal seam (Thomas, 2013).

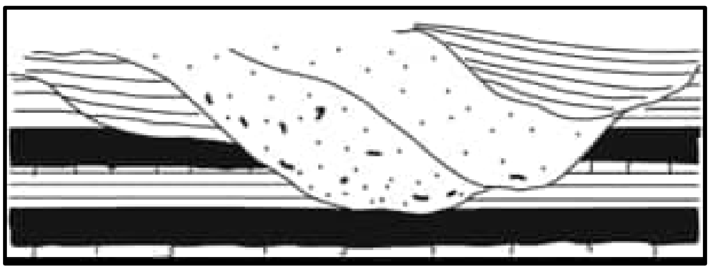

**Figure 3.** Washout structure in a coal seam (Thomas, 2013).

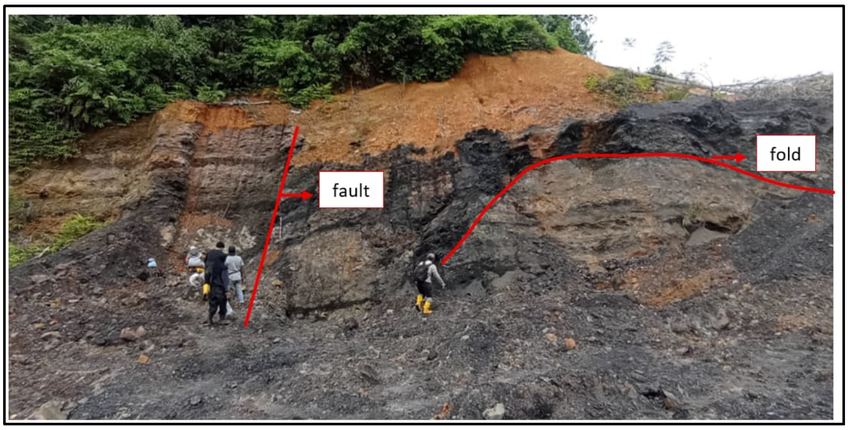


**Figure 4.** Folding and faulting in coal seams in the Merangin area, Jambi, highlighted in red in the image (Photograph by Rakhmatul Arafat, Tabir Ulu, Jambi, Indonesia, 2025).

## 3. RESEARCH METHODS

This study was conducted using both direct and indirect data collection methods. Direct observations included geological mapping conducted at a scale of 1:5,000. A total of 21 observation stations were investigated, where lithological, geomorphological, and structural geological data were systematically recorded. Measured stratigraphic sections were established at representative locations to characterize the vertical succession of rock units. In total, more than 20 rock samples were collected from the field, of which three representative samples were selected for petrographic analysis.

Petrographic analysis was performed using standard thin-section techniques under a polarizing microscope to verify lithological classifications and determine the mineralogical composition and textural characteristics of the rock units. Rock classification followed Pettijohn et al. (1975).

Indirect observations involved subsurface coal seam modeling using Minescape software based on exploration borehole data provided by PT Kuansing Inti Makmur. The dataset consisted of five boreholes with depths ranging from 40 to 60 m and borehole spacing ranging from 200 to 500 m, as shown by the red markers in **Figure 18**. Borehole correlation and three-dimensional seam modeling were performed to interpret the geometry and spatial continuity of the coal seams in the subsurface.

In general, the research methodology consisted of the following stages:

a. Literature review was conducted by collecting relevant publications related to the study area, particularly through the analysis of regional geological maps.
b. Direct field observation was carried out through geological mapping, including geomorphological observations, lithological mapping, structural geological analysis, and measured stratigraphic section logging.
c. Data analysis and processing were performed, including petrographic examination of rock samples.
d. Subsurface coal seam modeling was conducted using Minescape software.
e. Data presentation involved the integration and compilation of all obtained datasets into a coherent geological interpretation.

## 4. RESULTS AND DISCUSSION

### *4.1. Geomorphology of the Study Area*

Physiographically, the study area is located on the eastern flank of the Barisan Hill Anticlinorium. Based on landform characteristics, it is divided into the Structural Hills Unit (S1) and anthropogenic landforms consisting of the Mine Excavation Unit (A1) and the Waste Dump Unit (A2) (**Figure 5**). The Structural Hills Unit (S1) occupies approximately 15% of the study area, with elevations ranging from 120 to 150 m above sea level and moderate to moderately steep slopes. The morphology is controlled by regional tectonic uplift and subsequent erosion, where more resistant rock units form higher topographic features while less resistant lithologies are preferentially eroded.

The anthropogenic landforms comprise the Mine Excavation Unit (A1), covering approximately 40% of the study area, and the Waste Dump Unit (A2), covering about 45%. Both units were formed by extensive open-pit coal mining, which has substantially modified the original landscape, particularly within the sandstone and claystone units.

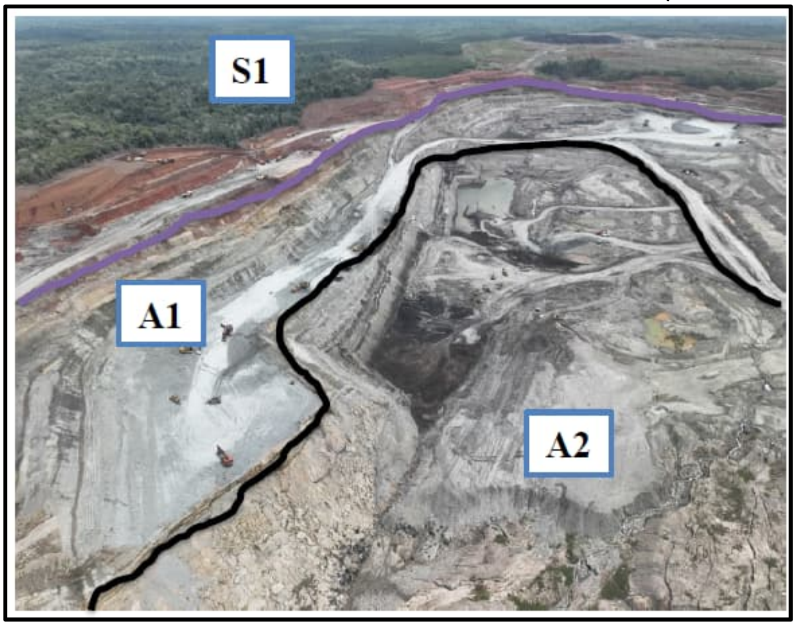


**Figure 5.** Structural Hills and Anthropogenic Landforms of the study area.

### *4.2. Stratigraphy of the Study Area*

Based on the geological mapping results, the study area is entirely composed of the Oligocene Sinamar Formation, which consists of the Sinamar Conglomerate Unit, Sinamar Sandstone Unit, and Sinamar Mudstone Unit. In this study area, shale was not identified, in contrast to previous findings by Tobing (2016) in Dusun Panjang, Tanah Tumbuh District, located to the west of the study area. This observation indicates an eastward change in depositional energy, reflecting a shift in depositional environments from lacustrine to fluvial and subsequently to deltaic settings. The lithological succession in the study area exhibits an overall coarsening-upward trend (**Figure 6**), suggesting a relative fall in sea level or a regressive phase.

| STRATIGRAPHIC COLUMN | | | | | |
|---|---|---|---|---|---|
| Age | | | Formation | Rock Unit and Lithology<br>Rock Lithology | Description |
| Cenozoicum | Paleogene | Oligocene | Pos | Sinamar Conglomerate Unit | Brownish-grey color with a massive structure, features andesite fragments with quartz and opaque mineral compositions. |
| | | | | Sinamar Sandstone Unit | Brownish-grey color with fine to medium grain size, also found with carbonate sandstone containing quartz, feldspar, and calcite mineral compositions. |
| | | | | Claystone Sandstone Unit | Dark grey color with quartz, opaque, and silica clay minerals. |

**Figure 6.** Stratigraphy of the Study Area.

The Sinamar Conglomerate Unit covers approximately 20% of the study area and is distributed in the northwestern, northern, and northeastern parts of the area. The Sinamar Sandstone Unit occupies about 25% of the study area, while the Sinamar Claystone Unit accounts for approximately 55% (**Figure 7**). A northeast–southwest geological cross-section based on the geological map indicates an upward-coarsening lithological succession (**Figure 8**).

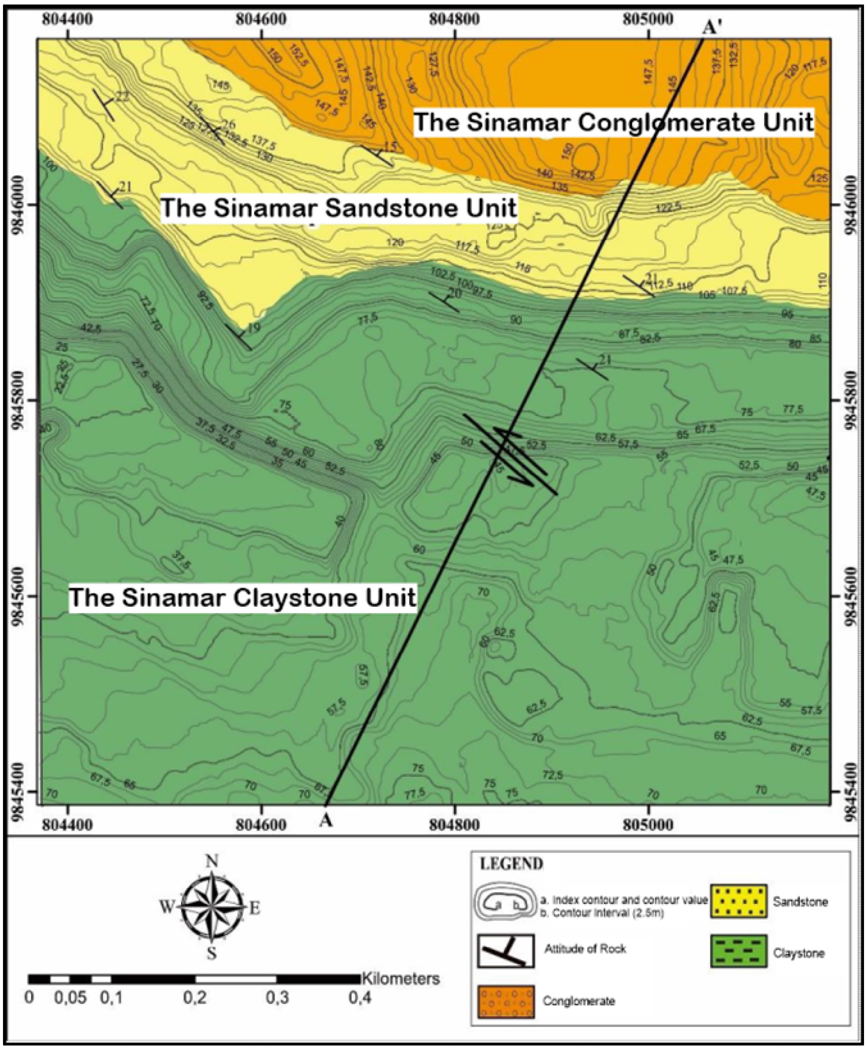


**Figure 7.** Geological map of the study area.

Megascopically, the Sinamar Conglomerate Unit exhibits a fresh color ranging from grayish-white to black, with a brownish weathered color. This rock unit is characterized by a massive structure and is composed of andesitic rock fragments (**Figure 9**).

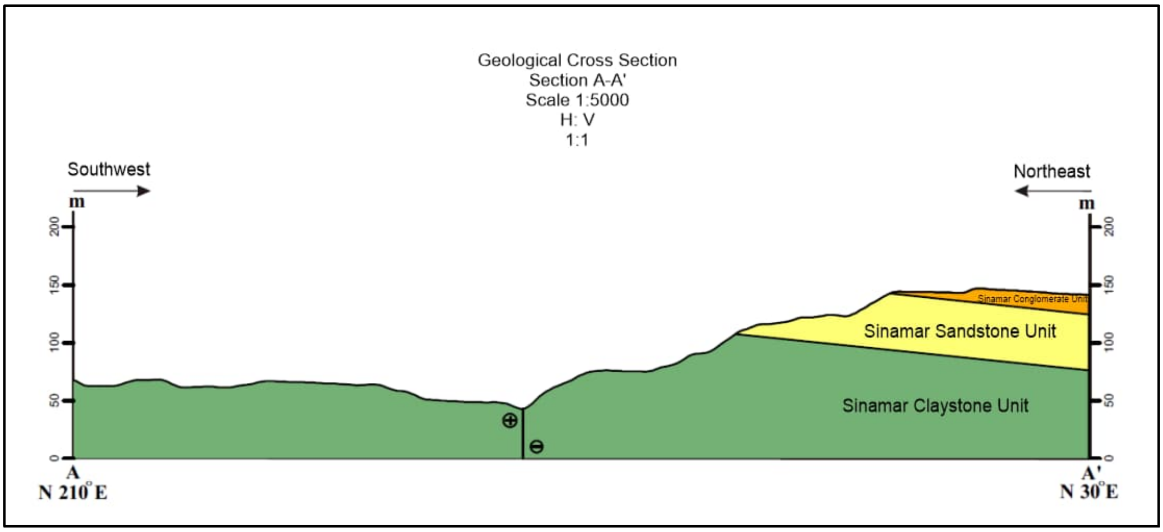


**Figure 8.** Geological Cross Section A-A' of the Study Area.


**Figure 9.** Outcrop photograph of the Sinamar Conglomerate Unit.

The outcrop of conglomerate is situated at UTM coordinates 804,400 mE and 9,846,105 mN and at this point, sampling was carried out for petrographic analysis. The locations of the three lithological units (conglomerate, sandstone, and claystone) in this study can be observed in **Figure 10**, indicated by red circles.

Microscopically, petrographic observations under PPL and XPL (10x ocular lens, 5x objective lens) show that the conglomerate has a massive structure, 2 mm grain size, poor sorting, and dense arrangement. This conglomerate consists of andesite rock fragments and contains plagioclase (J6) 35%, quartz (A10) 5%, hornblende (I3) 1%, clinopyroxene (I9) 1%, groundmass (E10) 54%, and opaque minerals (A1) 4% (**Figure 11**).

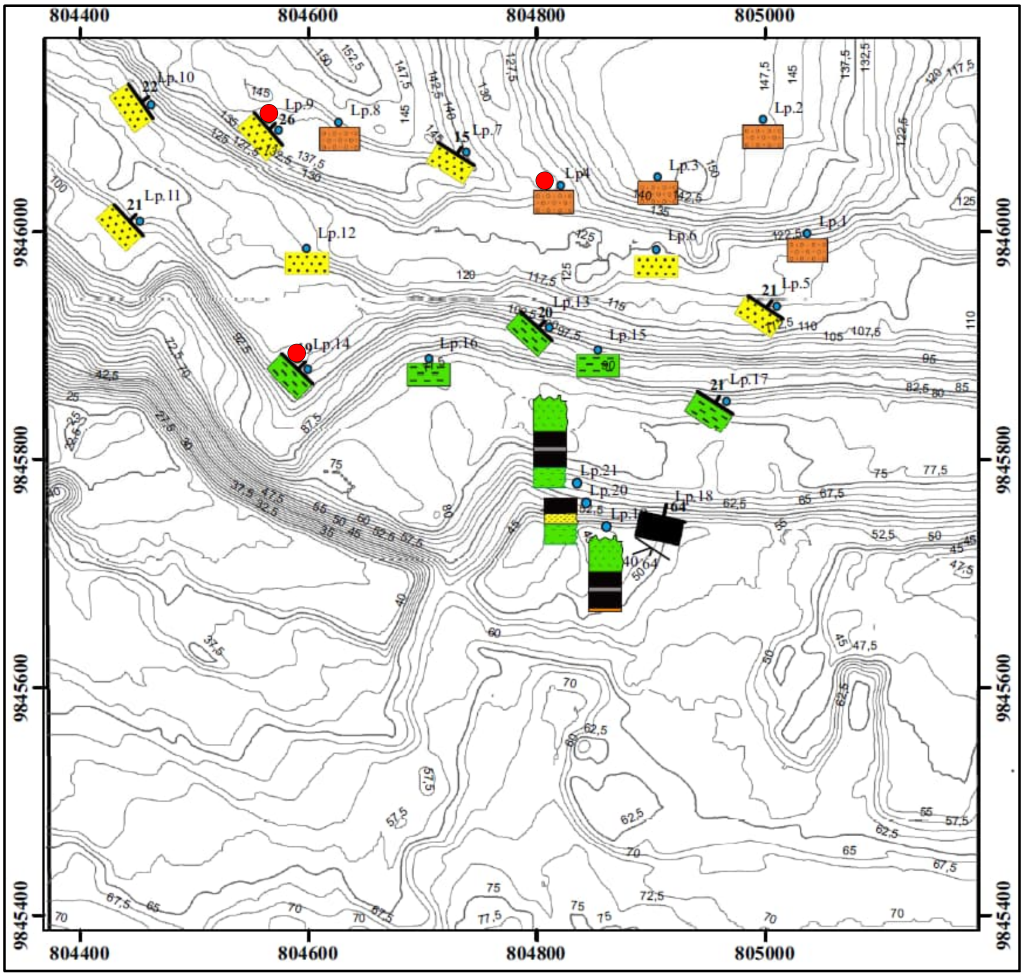

Figure 10. Sampling locations in three rock units are marked with red circles in the figure.

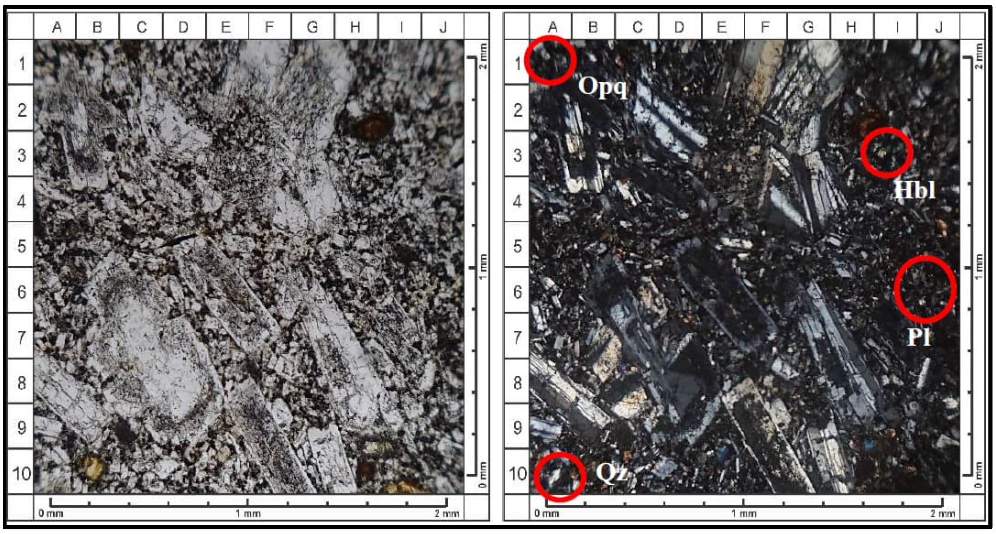

Figure 11. Photomicrographs of the Sinamar Conglomerate fragment under PPL and XPL.

The conglomerate matrix is composed of lithic tuff, with the following mineral composition: lithic fragments (J10) 70%, quartz (B6) 1%, glauconite (F2) 3%, volcanic glass (A2) 24%, and opaque minerals (B1) 2% (**Figure 12**).

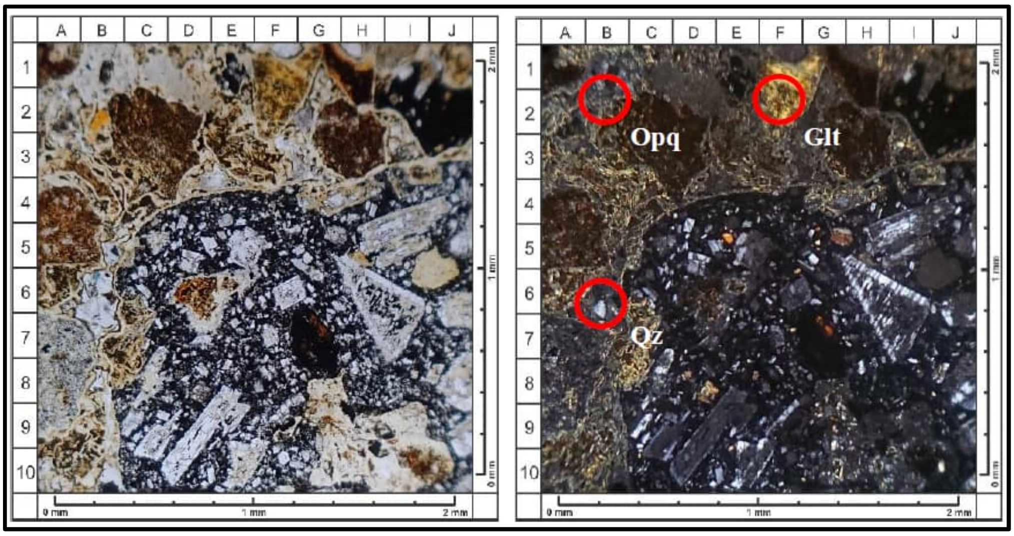


**Figure 12.** Photomicrographs of the Sinamar Conglomerate matrix under PPL and XPL.

The occurrence of conglomerates composed of poorly sorted andesite fragments indicates relatively short transport distances from a proximal source area. The dominance of volcanic andesitic clasts, together with a lithic tuff matrix containing volcanic glass, suggests that volcanic materials derived from the Barisan Range were deposited within the basin during sedimentation. The presence of conglomerates indicates that the Sinamar Conglomerate Unit was deposited in a high-energy alluvial fan environment. The location of the study area on the eastern flank of the Barisan Anticlinorium further supports the interpretation that these volcanic materials originated from the Barisan Range.

The Sinamar Sandstone Unit consists of massive, well-sorted, very fine- to medium-grained sandstone (<1/32–0.7 mm) with a grain-supported, closed-packing fabric. Petrographic analysis indicates that the sandstone comprises calcite (47%), quartz (30%), glauconite (10%), fossil fragments (4%), lithic fragments (4%), feldspar (4%), and opaque minerals (1%) (**Figure 14**).

The Sinamar Sandstone Unit is better sorted than the conglomerate, indicating longer transport and more stable depositional energy. The presence of fossils, glauconite, and abundant calcite indicates marine influence, suggesting deposition in a transitional to shallow marine environment, most likely a delta front.

The Sinamar claystone unit dominates the study area. It is dark gray in color, and the outcrop is located at UTM coordinates 804,639 mE and 9,845,784 mN (**Figure 15**). Microscopically, the rock exhibits a massive structure with grain sizes ranging from <1/256 to 1/24 mm, well sorted, and open-packed. It comprises 95% siliceous clay (A10), 1% quartz (D7), 1% opaque minerals (D1), and 3% fractures (A7) (**Figure 16**).


**Figure 13.** Outcrop photograph of the Sinamar Sandstone Unit.

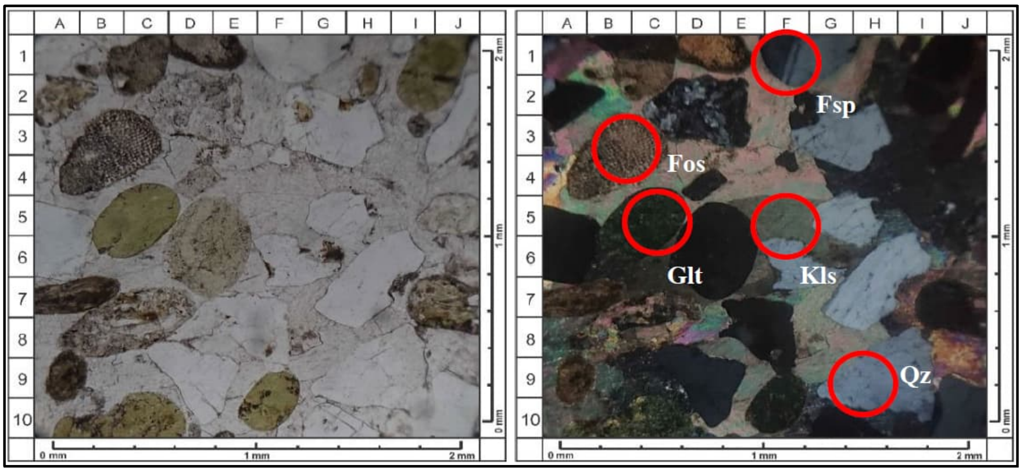


**Figure 14.** Photomicrographs of the Sinamar Sandstone outcrop sample under PPL and XPL.


**Figure 15.** Outcrop photograph of the Sinamar Claystone Unit.

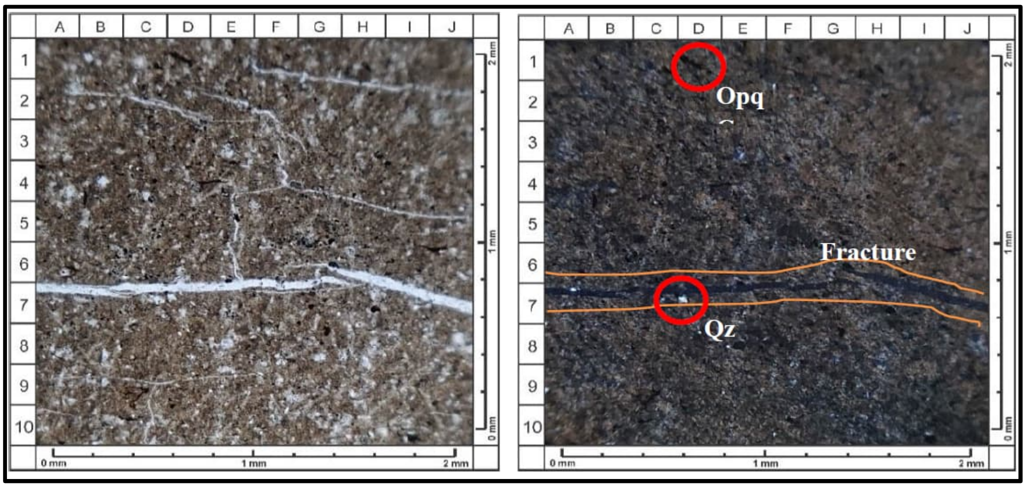


**Figure 16.** Photomicrographs of the Sinamar Claystone outcrop sample under PPL and XPL.

The Sinamar Claystone Unit is the most dominant lithology in the research area and is composed of very fine-grained materials with a high silica clay content. These characteristics indicate deposition in a low-energy environment, such as a floodplain, swamp, lagoon, or the lower part of a delta system. These conditions also favored organic matter accumulation, leading to coal seam formation. Coal seams associated with the claystone and sandstone units indicate repeated swamp development interrupted by episodes of clastic sedimentation during the Oligocene.

### *4.3. Geological Structure of the Study Area*

A geological structure in the form of a fault was identified within the study area. Field measurements indicate that the fault plane has an orientation of N168°E/64°. The slickenside lineation exhibits a trend of N210°E with a rake of 42° measured on the fault plane. Based on stereographic analysis of the fault plane and slickenside data, the structure is interpreted as a normal-left slip fault (**Figure 17**).

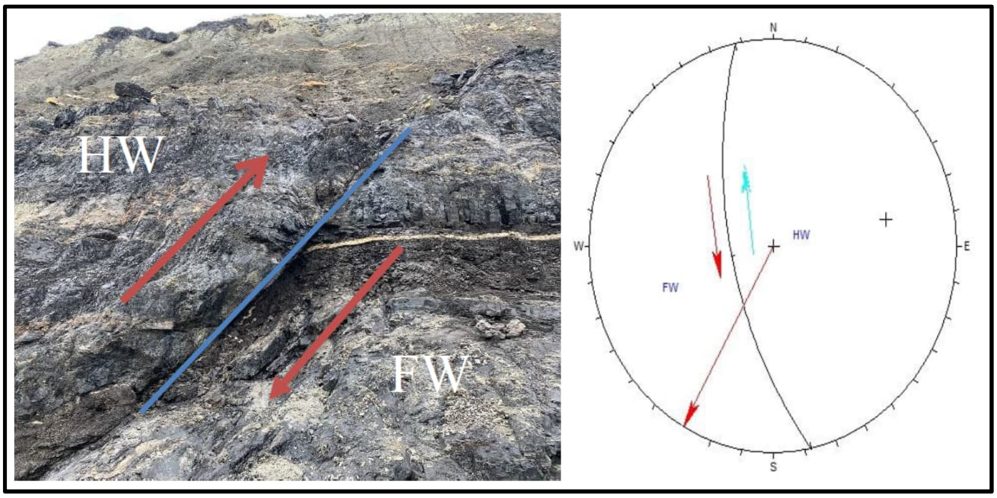


**Figure 17.** Stereographic analysis of the identified fault.

The presence of this normal-left slip fault indicates that the study area experienced tectonic deformation after the deposition of the Sinamar Formation. Regionally, the location of the study area on the eastern flank of the Barisan Range Anticlinorium and within the transition zone between the Ombilin and South Sumatra basins suggests that this deformation is related to the tectonic evolution of Sumatra, controlled by the Sumatran Fault System.

### *4.4. Coal Distribution Patterns*

Based on the layer attitude (strike/dip) and drilling data, crop lines were determined using the structural contour method. Three coal seams striking Northwest–Southeast were identified from the drilling data and designated as Seam A, Seam B, and Seam C. This distribution pattern is consistent with the orientation of the Sinamar Formation sedimentary layers (**Figure 18**). Coal seams occur within the Sinamar Claystone Unit and the Sinamar Sandstone Unit, whereas no coal seams were found in the Sinamar Conglomerate Unit. This indicates coal formation in a low to moderate-energy depositional environment favorable for organic matter accumulation.

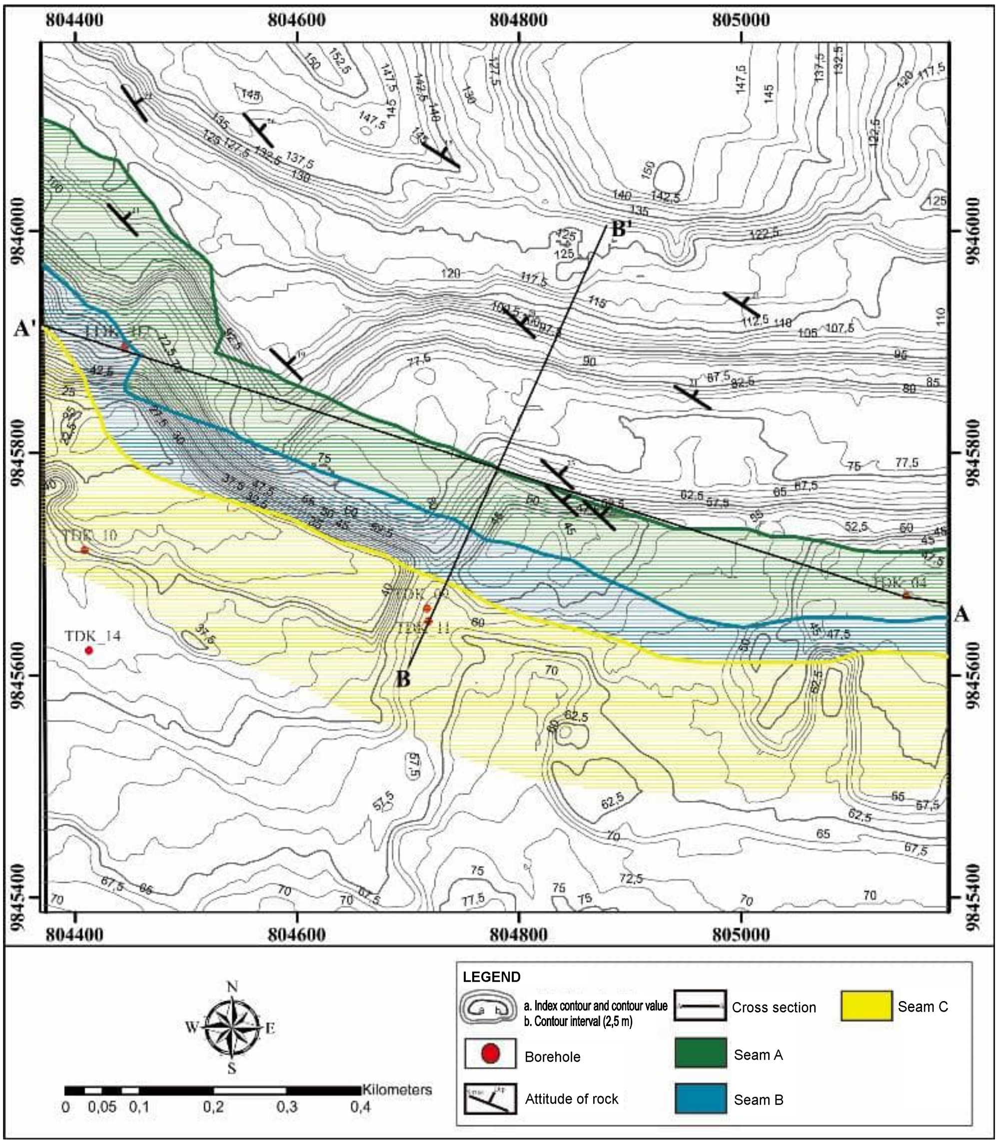


**Figure 18.** Coal seam distribution pattern map of the study area derived from borehole data provided by PT Kuansing Inti Makmur and generated through subsurface modeling using Minescape software.

The exposed coal is black with a brownish-black streak, dull luster, good hardness, and well-developed cleavage. Impurities consist of calcareous partings and resin, the latter indicating a contribution from terrestrial vegetation during peat formation. Carbonaceous partings indicate interruptions in peat accumulation caused by inorganic sediment input into the swamp environment, suggesting that peat formation was periodically interrupted by sedimentation events that produced impurity layers within the coal seams.

Using Minescape software, subsurface cross-sections of the coal seams were constructed based on the previously prepared Coal Distribution Map (**Figure 18**). The first cross-section (Section A–A') was drawn parallel to the strike direction (**Figure 19**), whereas the second cross-section (Section B–B') was drawn perpendicular to the strike direction, or parallel to the dip direction (**Figure 20**).

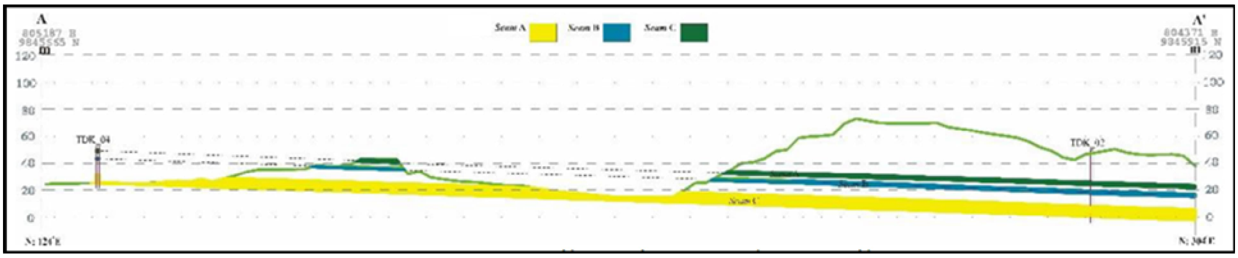

**Figure 19.** Subsurface model of the coal seams in a cross-section parallel to the strike, provided by PT Kuansing Inti Makmur and generated using Minescape software.

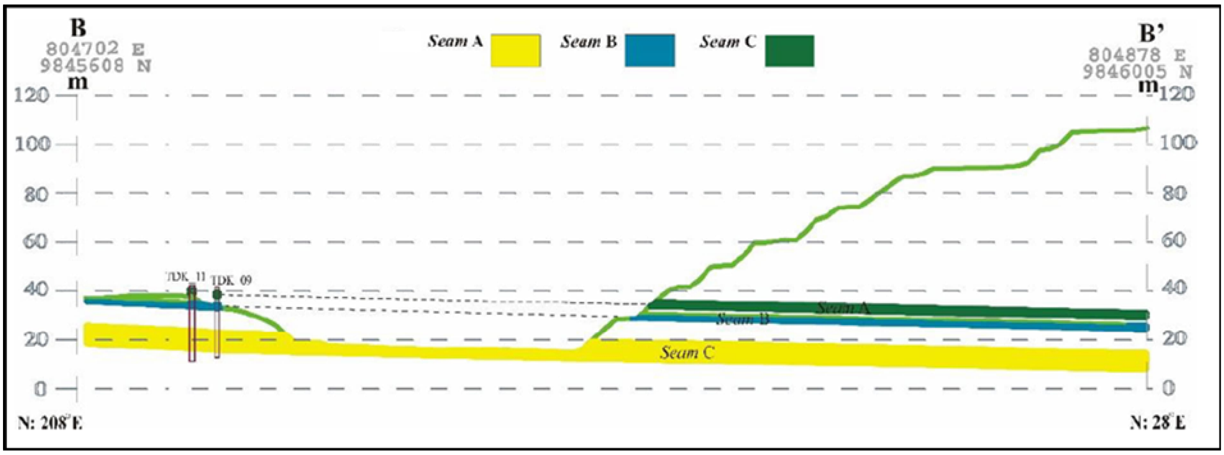


**Figure 20.** Subsurface model of the coal seams in a cross-section perpendicular to the strike (dip-oriented), provided by PT Kuansing Inti Makmur and generated using Minescape software.

The subsurface model shows that coal seam thickness varies from 1.5 m (Seam B) to 6 m (Seam C). The coal seams strike northwest–southeast, ranging from N293° to N305°, with dip angles of 23–30°. These dips are steeper than those reported for the Sinamar Formation shale beds in Rantau Panjang Village, Tanah Tumbuh District, which range from approximately 15° to 23° (Tobing, 2016). The relatively steeper bedding dip observed in the study area, compared to surrounding areas, is interpreted to reflect the influence of tectonic activity and local geological structures. Nevertheless, the structural complexity of the study area is still considered to be moderate, as the bedding attitudes have not undergone intense deformation. Therefore, despite the limited borehole dataset, which introduces uncertainty, particularly in areas with sparse borehole control, the lateral continuity of the coal seams can still be reasonably predicted and corelated along the strike direction. This interpretation is supported by bedding orientation data (strike and dip), lithological information obtained from boreholes, and geological mapping.

## 5. CONCLUSION

Based on the results of geological mapping and subsurface modeling conducted in Jujuhan Subdistrict, Bungo Regency, the study area is entirely composed of Oligocene-aged rocks of the Sinamar Formation, which comprises the Sinamar Conglomerate Unit, Sinamar Sandstone Unit, and Sinamar Claystone Unit. The area consists of Structural Hill (S1), Mine Excavation (S2), and Waste Dump (S3) geomorphological units, with an upward-coarsening stratigraphic succession indicating increasing depositional energy. The identified normal-left slip fault reflects post-depositional tectonic deformation affecting the Sinamar Formation.

The distribution of coal within the Sinamar Formation is controlled by both stratigraphic and structural factors. Based on the correlation between borehole data and surface observations, coal seams occur within the Sinamar Claystone and Sandstone Units, while no coal was identified in the Sinamar Conglomerate Unit. Three coal seams (Seam A, Seam B, and Seam C) were identified, trending northwest–southeast (N293°E–N305°E) with dips of 23°–30°. Coal thickness ranges from 1.5 to 6 m, with Seam C as the thickest seam. Subsurface modeling indicates that coal distribution follows the bedding orientation of the Sinamar Formation and reflects deposition in low-energy swamp to delta-plain environments that were intermittently influenced by clastic input during sedimentation. The relatively steep dip of the coal seams in the study area is interpreted to be the result of local structural deformation, including folding and faulting.

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