E-ISSN : 2541-5794
P-ISSN : 2503-216X

Journal of Geoscience,
Engineering, Environment, and Technology
Vol 9 No 4 2024

RESEARCH ARTICLE

Recognizing Synrift and Postrift Structures on Rock Exposures in The Tanjung Aur II Region, South Bengkulu, Indonesia

Rio Hanzra Adjie Pamungkas [1]*, Edy Sutriyono[1]

[1] *Geological Engineering Department, Engineering Faculty, Sriwijaya University, Indralaya, South Sumatra, Indonesia*

* Corresponding author : 03071382025043@student.unsri.ac.id
Tel:+62-812 7930 3854
Received: Oct 09, 2024; Accepted: Nov 21, 2024.
DOI: 10.25299/jgeet.2024.9.04.14528

Abstract

Field observation has been carried out recently in the Tanjung Aur II region, South Bengkulu in order to recognize the structural configuration of rock sequences, employing two fundamental approaches such as the analysis of Digital Elevation Model (DEM) and the surface mapping, particularly on geological structures. The DEM analysis reveals two general patterns of the NE-SW and NW-SE lineaments. The NE-SW trend appears consistent with the structural features resulted from the WNW-directed rifting event, whereas the NW-SE orientation seems coincident with the general strike of the Bengkulu Basin. The field mapping has recognized five types of brittle structures and two ductile deformations. The outcropping brittle deformation includes the Tanjung Aur II-A listric extensional fault, Tanjung Aur II-B listric extensional fault, Tanjung Aur II-C domino extensional fault, and Tanjung Aur II-D listric extensional fault that all strike to NE-SW, and the Air Selali compressional fault which trends to NW-SE. The recognized ductile structures are those of the Air Kenidian Anticline and Syncline, which have a general trend to NW-SE. Importantly, the encountered structures suggest two distinct episodes of tectonic events, transtension and transpression. The transtensional regime associated with the WNW extension of rifting. The synrift event commenced in Paleogene or Paleocene-Eocene time, and proceeded up to Neogene. Hence, the sedimentary influx within the basin had likely been accommodated by the occurring tectonic deformation which resulted in the synrift listric extensional faults. The transpressional regime in the study area led to ductile deformation responsible for thrusting and folding of sedimentary sequences. This post-rifting episode perhaps associated with the onset of Barisan orogeny that allowed inversion of sedimentary basin in Late Neogene or Plio-Pleistocene time. Herein, this tectonic episode is considered as the last event that caused the rock successions to be uplifted and the generated structures in rock units to be exposed at the surface due mainly to denudation and erosion.

Keywords: Bengkulu basin, deformation, synrift, postrift, structure.

1. Introduction

The present study aims at recognizing tectonic structures recorded within rock sequences of the region. Field observation was undertaken to identify and to measure structural elements on rock exposures. The surface data gained from the area were then combined with the results of imagery analysis using Digital Elevation Model (DEM) to delineate particularly the lateral continuation along the measured strike of structures. Administratively, the region is situated in the Pino Raya District, South Bengkulu Regency, Bengkulu Province, mainly within the geographical coordinates between 265774 E - 9535494 N and 274774 E - 9526497 N. In addition, the area of this study is regionally located within the Bengkulu basin, which is tectonically situated in the fore-arc setting that stretches to the NW-SE direction at the western margin of Sumatra (**Fig.1**).

The tectonic setting of the basin is very complex, generally attributed to different tectonic regimes, ranging from extension causing subsidence of the depocenter to compression leading to inversion of the region (Kusnama et al., 1993; Mukti, 2011; Yulihanto et al., 1995). The initial development of the subsiding basin occurred during Paleogene, coincident with the onset of extensional stresses that took place regionally at most portion of the island, such as those existed in the back-arc setting that extends along the eastern margin of Sumatra, including North Sumatra basin, Central Sumatra basin and South Sumatra basin (**Fig.1**) (Barber and Crow, 2003; Daly et al., 1991; Howles, 1984). Subsequent development of the basin was due principally to a compressional regime during the Neogene, which has been responsible for the inversion of the depocenter, as well as regionally the uplift of Barisan Mountain Range, known as Barisan Orogeny (Hall, 2014; Simandjuntak and Barber, 1996). More importantly, both extensional and compressional regimes have to some extent deformed sedimentary rock sequences within the basin prior to being exposed due mainly to erosional denudation.

However, Yulihanto et al (1995) considered that the evolution of the basin has been related to the movement of Semangko Fault System (SFS) and Mentawai Fault System (MFS). Sieh and Natawidjaja, (2000) divided the SFS from the south to the north section into the Komering, Manna, Musi, and Ketaun segments. With respect to this division, the studied region is situated at the southern part of the Manna fault and shows mountainous terrains in the eastern fault zone, hence the area is very complex structurally. The complexity of the region has also been proved specifically by a record of the seismic activity commenced in 1893, which reveals that the existing fault in this particular area is still active (Natawidjaja, 2010). This implies that the deformation of the region proceeds through time, hence the rock successions have been deformed primarily by faulting and folding (Fajri et al., 2019; Zuhri and Sutriyono, 2020). Little has been conducted in-depth work emphasizing particularly on the structure of the Tanjung Aur II region in South Bengkulu, therefore it is important to undertake research in the detailed scales in order to better understand the deformation history and tectonic evolution of the region. The present study focuses on observation and measurement structural components on outcrops to recognize types of structuring and episodes of tectonic deformation.

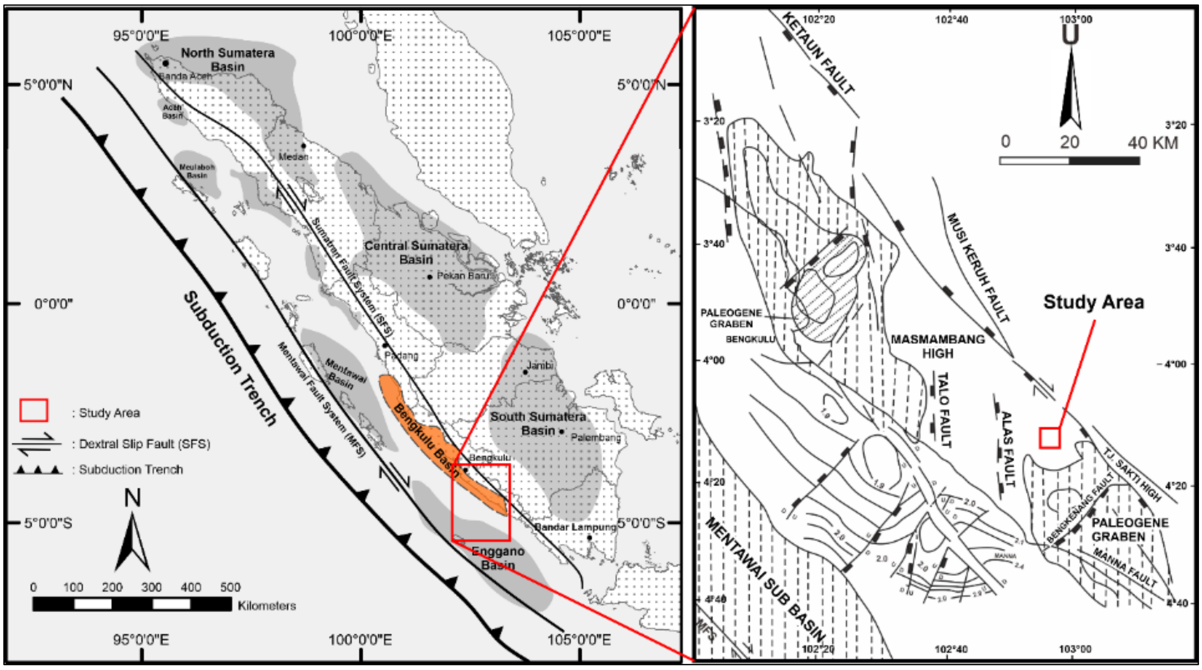

Fig 1. Map showing a regional tectonic setting of Sumatra (left), and the present study area situated in the Bengkulu Basin (right). Also shown the back-arc basins at the eastern margin of the islands (modified from Barber and Crow, 2003; Yulihanto et al., 1995).

2. Brief Overview of Geology

In the study area there appeared three stratigraphic units, namely Seblat Formation, Lemau Formation, and Simpangaur Formation. The depositional evolution presented in the recent work principally refers to the previous study reported by Yulihanto et al (1995). The Early-Middle Miocene Seblat Formation is constituted by the rock section that characterize an environmental shift from fluviatile to marine. Thus, the unit suggests that the sequence was deposited during a short period of transgressive event, which occurred as the basin continued subsiding in early Neogene time.

The overlying Middle-Late Miocene Lemau succession composes mainly of claystone, sandstone, calcareous sandstone, and mollusk-bearing sandstone. These rocks were deposited in shallow marine and transitional environments, suggesting a decline in sea level or regression. This regressive event proceeded up to the Late Miocene-Pliocene, and deposited clastic materials such as sandstone and sandstone with mollusk shell fragments, which formed the Simpangaur Formation.

According to Yulihanto et al (1995), the recorded tectonic deformation within the Bengkulu basin can be differentiated into the NW-SE trending and the NE-SW striking structures. Dextral lateral faults such as Tanjung Sakti Fault, Ketaun Fault, and Manna Fault are considered as the faulting system that had been responsible for the development of the Pagarjati graben in the NW section, and the Kedurang graben in the NW sector.

The recent region studied seems to have been controlled regionally by the Tanjung Sakti fault system, which forms the southern portion of the SFS. The movement of the fault has resulted in the NW-SE and NE-SW oriented structural features. The NW-SE structures include the Air Kenidian anticline and syncline, and Air Selali fault, whereas the NE-SW deformational configurations are those of four faults such as the Tanjung Aur II-A, Tanjung Aur II-B, Tanjung Aur II-C, and Tanjung Aur II-D.

3. Methods

The present study emphasizes on recognizing geological structures recorded by rock sequences that have been exposed within the region. Hence, field observation was conducted particularly on the exposures, in which measurements were undertaken to gain structural elements for classification. In order to delineate the strike of structures, this work employed an analysis of Digital Elevation Model (DEM).

The DEM map was generated by employing two computer-aided programs such as Global Mapper and ArcGIS, and using elevation data. The data are available at the DEMNas website, which is under the management of the Indonesian Geographic Information Agency. Using the generated DEMNas map, the structural features are identified on the basis of two aspects, lineaments with either positive or negative relief. Shadows of topographic relief are interpreted as the lineament of highlands or high cliffs, whereas valley and river patterns are considered as the lineament of the negative landforms (Seleem, 2013; Setiawan and Goestyananda, 2022). Relatively, long lineaments characterize the presence of geological structures, whereas river lineaments are dominated by the same pattern of ridge direction in each segment and generally show a shorter shape with opposite directions (Hidayatillah et al., 2024; Syahputra et al., 2019).

Field geological mapping was undertaken principally to observe the outcropping rocks that recorded tectonic structures. The structural elements of the exposures were measured and documented following the techniques described by McClay (1988) to determine structural classification. In addition, a computer-aided program utilized in the present study includes Dips 6.0, Wintensor 5.0.1, Visible Geology, and Georose.

4. Results

Paleogene and Neogene tectonic events appeared to have controlled on the occurrence of ductile and brittle deformation in the study area. Brittle deformation such as faulting occurred in the competent layers of the Lemau Formation, whereas ductile structuring that formed folding took place in the incompetent layers of the Seblat Formation. The study area reveals several structural elements, including anticline, syncline, thrust fault, and normal faults. The structure trends NE-SW, similar to the formation of the Paleogene Graben System, and NW-SE parallel to the Barisan Mountain Range. This suggests that the deformation of sequence took place during and or after rifting, hence resulted in synrift and postrift structures. **Fig. 2** shows the lineament pattern interpreted from the DEMNas map and the location of the field observations on outcrops at the Tanjung Aur II region, and displays a general orientation of lineament based on the rose diagram.

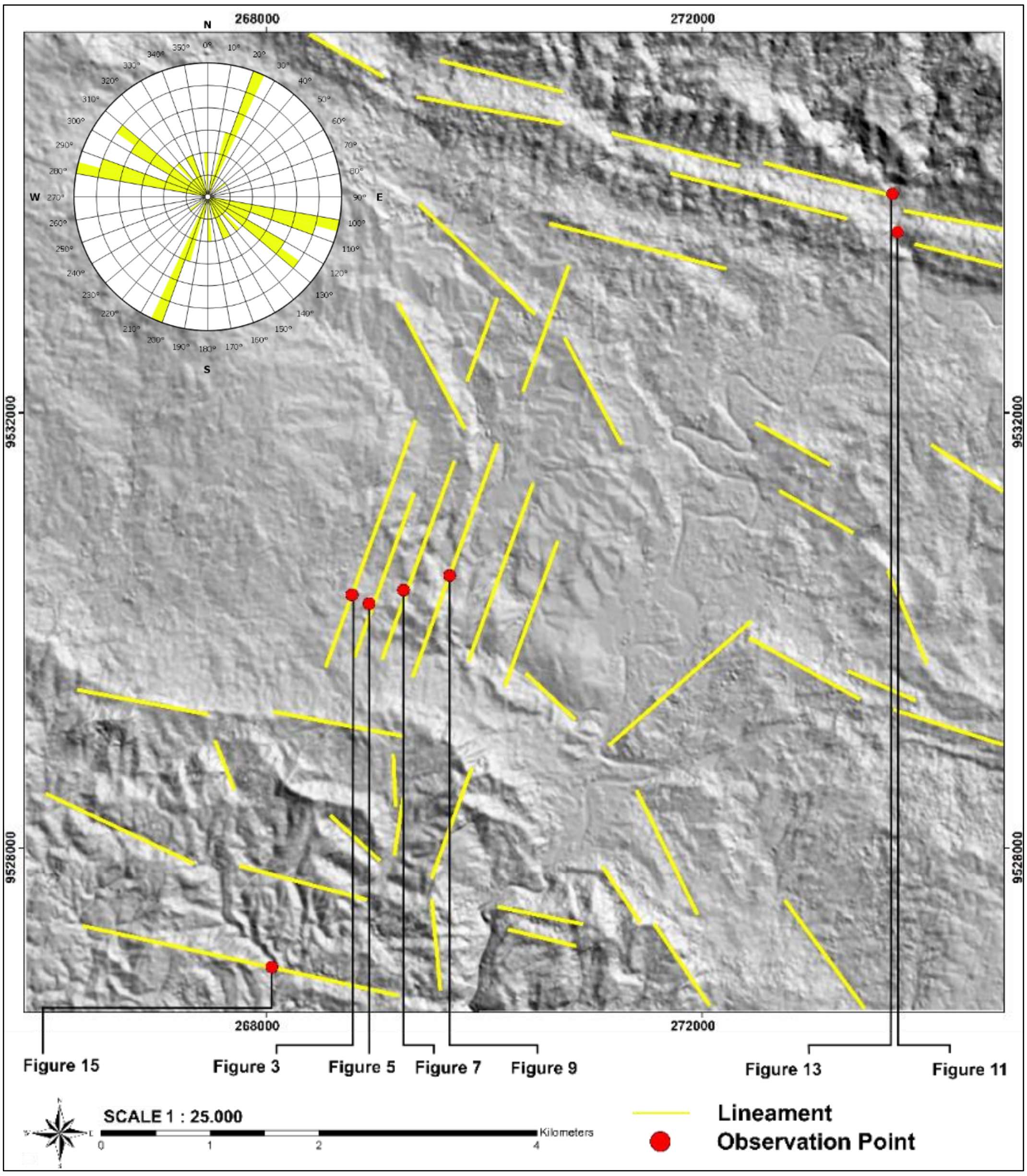

Fig 2. Lineament pattern interpreted from the DEMNas Map and the locations of structural outcrops observed in the study area. Also shown is a rose diagram showing general orientations of lineaments to the NE – SW and NW – SE directions (inside the map).

There are four structures recognized in the region that strike to the NE-SW direction, namely the Tanjung Aur II-A Fault, Tanjung Aur II-B Fault, Tanjung Aur II-C Fault, and Tanjung Aur II-D Fault. This extensional faulting appeared in the western section of the region. Whereas, the compressional structuring, which resulted in the Air Kenidian Anticline, Air Kenidian Syncline, and Air Selali Kecil Fault developed in the NE and SW areas.

4.1 Tanjung Aur II-A Fault

This fault is exposed to the west of the study area and strikes to NE-SW or N200°E. The faulting resulted in a bedding offset and a fracture plane stepping on the Hangingwall (Hw) block of calcareous sandstone and intercalated sandstone and mudstone of the Lemau Formation (**Fig 3**). Measurements of structural components indicate that the fault is a normal fault controlled by a transtensional regime. The geometry of the fault plane shows a different dip ranging from 65° at the upper part to 48° in the middle section and 25° at the lower segment. Thus, the fault is steeper at the upper stratigraphic section. According to McClay (1988) such a curved faulting suggests a listric extensional fault. It is interpreted that the deformation might have taken place during the sedimentation process.

Analysis using a stereographic diagram reveals that the main stress (σ_1) direction responsible for faulting is 68°, N182°E and the minimum stress (σ_3) 17°, N041°E (**Fig. 4**). This indicates that the structure is vertical dip-slip fault (Fossen, 2010).

Fig 3. The outcrop in the Tanjung Aur II-A region showing a normal fault steeper at the upper stratigraphic level interpreted as a listric extensional fault (left). Also shown are slickensides stepping to NW (right).

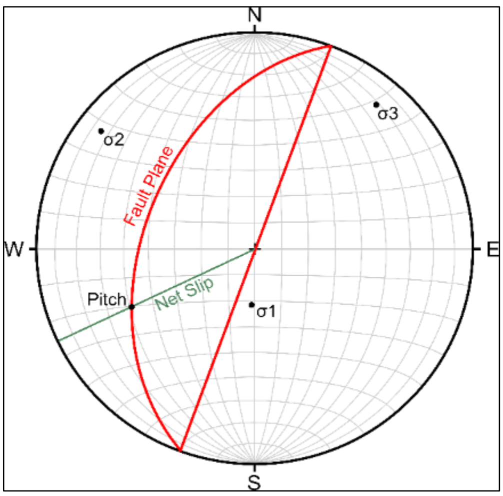

Fig 4. Stereographic Analysis of the Tanjung Aur II-A Fault.

4.2 Tanjung Aur II-B Fault

This fault is exposed to the western section of the study area and strikes to NE-SW or N200°E. The faulting resulted in a bedding offset and a fracture plane stepping on the Hangingwall (Hw) block of calcareous sandstone and intercalated sandstone and mudstone of the Lemau Formation (**Fig 5**). Based on the results of measurement on structural components, it can be recognized that the structure is a normal fault. The development of the extensional fault was likely to have been controlled by the transtensional regime. The geometry of the fault plane shows different dips, ranging from 65° at the upper part to 32° in the middle section and 21° at the lower segment. Thus, the fault is steeper towards the upper level of stratigraphy, interpreted as a listric extensional fault (McClay, 1988). In addition, it is suggested that the deformation was likely to occur during the sedimentation process, since the rock unit in the hangingwall section is thicker than that in the footwall block. This implies that the fault may be one of the synrift structures within the graben system.

Analysis using a stereographic diagram reveals that the main stress (σ_1) direction responsible for faulting is about 64°, N212°E and the minimum stress (σ_3) 23°, N063°E (**Fig 6**). This indicates that the structure is a vertical dip-slip fault (Fossen, 2010).

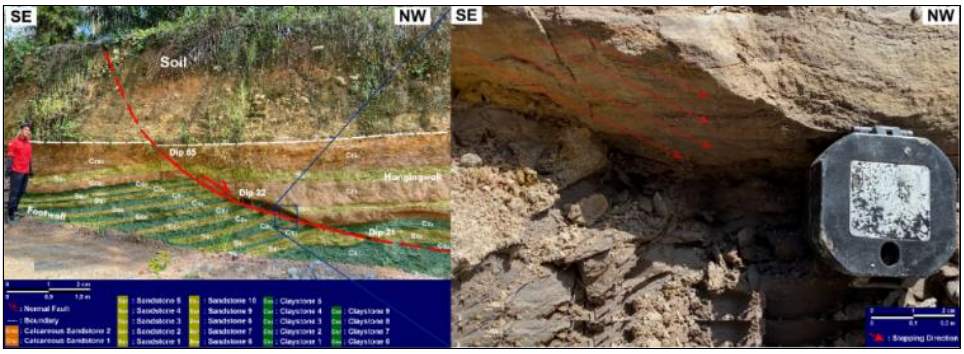

Fig 5. The exposure of listric extensional fault at the Tanjung Aur II-B region (left). Also shown is a fault plane showing slickensides stepping to NNW (right).

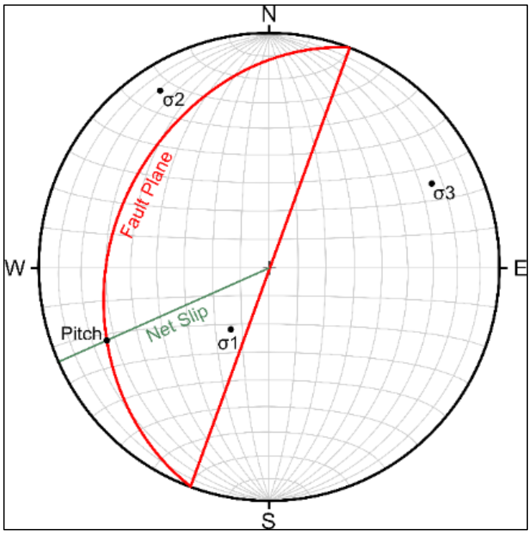

Fig 6. Stereographic Analysis of the Tanjung Aur II-B Fault.

4.3 Tanjung Aur II-C Fault

In this particular site, a pair of extensional faults are exposed, strike to NE-SW or N200°E, and show planar fault planes. The geometry of the structure suggests a rotational extensional fault or a domino extensional fault (McClay, 1988). The faulting has displaced calcareous sandstone and claystone of the Lemau Formation (**Fig 7**). In addition, the claystone unit in the hangingwall block is thicker than that in the footwall block. This suggests that the episode of faulting was coincident with the period of Lemau sedimentation in Middle-Late Miocene time. Furthermore, it is interpreted that faulting was likely to have associated with a transtensional regime responsible for rifting, as well as graben development during Neogene time.

Analysis utilizing a stereographic diagram reveals that the main stress (σ_1) direction responsible for faulting is 85°, N090°E and the minimum stress (σ_3) is 05°, N296°E (**Fig 8**). This indicates that the structure is a vertical dip-slip fault (Fossen, 2010).

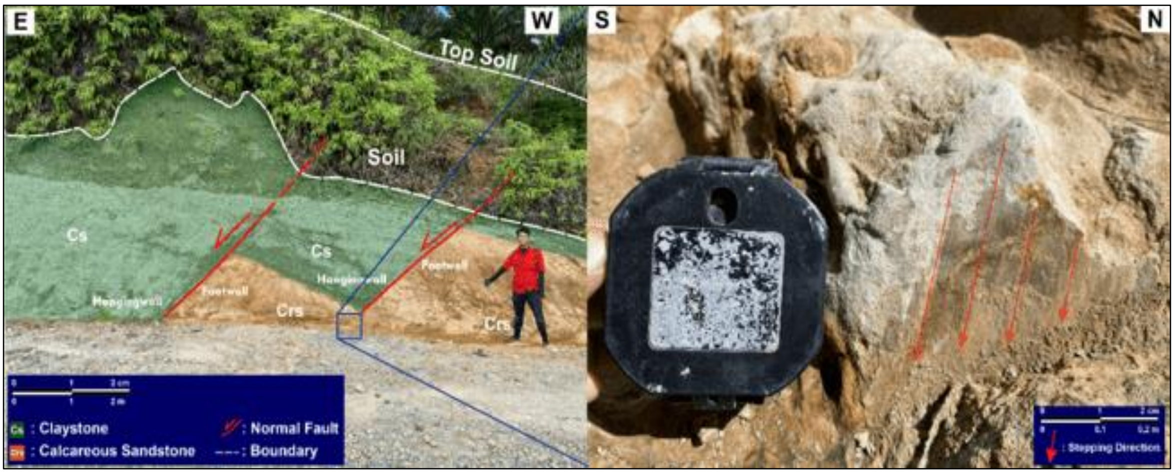

Fig 7. A pair of normal faults exposed in the Tanjung Aur II-C site showing parallel planar fault planes, suggesting domino extensional faulting (left). Also shown is fault plane with slickensides stepping to E (right).

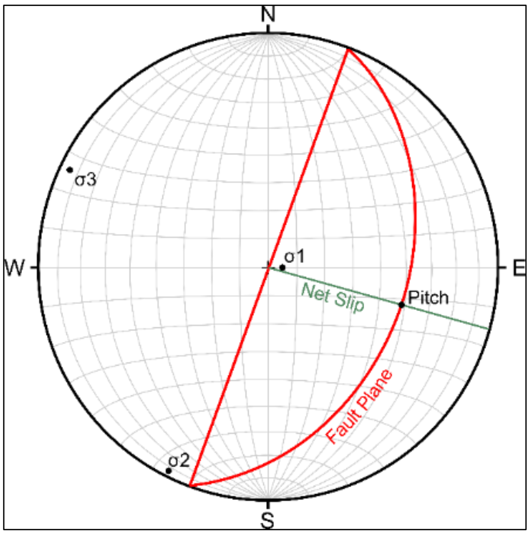

Fig 8. Stereographic Analysis of the Tanjung Aur II-C Fault.

4.4 Tanjung Aur II-D Fault

This fault is exposed in the western sector of the study area and strikes to NE-SW or N200°E. The faulting resulted in the offset of beds and the fault plane, which displaced the calcareous sandstone and intercalated sandstone and mudstone of the Lemau Formation (**Fig 9**). The geometry of the observed structure suggests a normal fault that formed due principally to transtensional stresses. Importantly, the measured fault plane reveals that it is steeper upward in the stratigraphic level from 23° in the lower segment, 48° in the middle part to 65° in the upper portion, suggesting a listric extensional fault (McClay, 1988). Again, the listric normal fault within the region suggests the synrift structuring that occurred during the formation of graben system.

Analysis using a stereographic diagram reveals that the main stress (σ_1) direction responsible for faulting is 84°, N164°E and the minimum stress (σ_3) is 05°, N303°E (**Fig 10**). This indicates that the structure is a vertical dip-slip fault (Fossen, 2010).

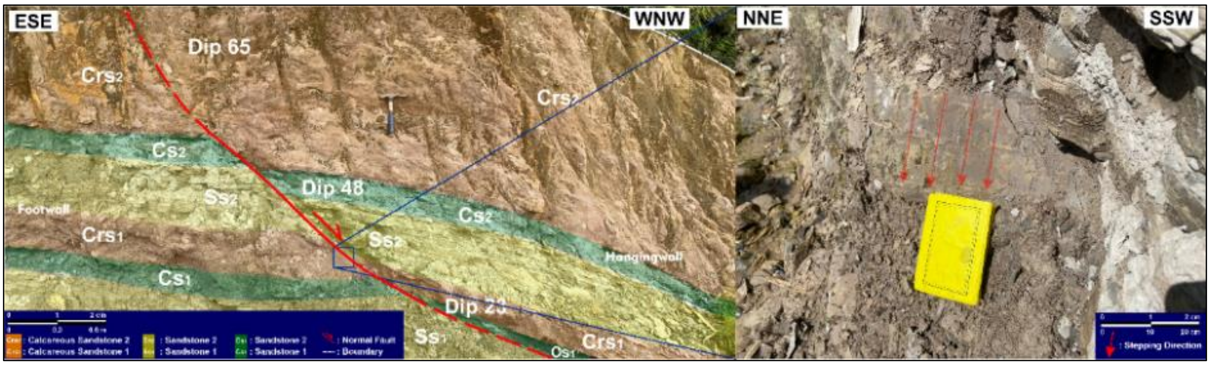

Fig 9. Listric normal fault encountered in the Tanjung Aur II-D region showing steeper dip at the upper stratigraphic level (left); also shown is a fault plane with slickensides stepping to WNW (right).

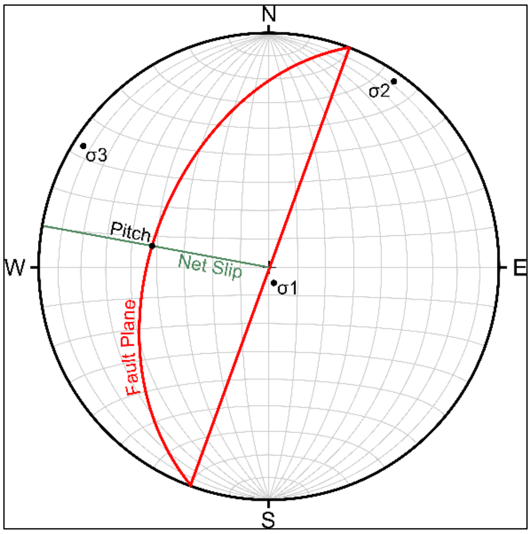

Fig 10. Stereographic Analysis of the Tanjung Aur II-D Fault.

4.5 Air Kenidian Anticline

In the Air Kenidian river there appears a folding feature that trends to NW-SE or N113°E. This compressional structure suggests a ductile deformation, which involved the sandstone units of the Seblat Formation. The sandstones differ in grain sizes, units Ss_1, Ss_3, and Ss_5 are medium-grain sized sandstones, whereas layers Ss_2, Ss_4, and Ss_6 are fine-grain sized sandstones. The measured structural components show the SSW limb 89°, the NNE limb 27°, the interlimb angle 62° (close fold), and the fold axis angle 62° (steeply inclined fold). These data suggest an asymmetrical anticline (**Fig. 11**). This asymmetrical anticline plunges 30° (gently plunging) to NNW. In addition, the anticlinal fold has an angular hinge surface, hence it can be classified as asymmetrical kink fold or kink band (Fossen, 2010; Hudleston, 1986; Richard, 2004). It is therefore the Air Kenidian folding structure in the present study is described as an asymmetrical plunging kink band.

Analysis using a stereographic diagram reveals that the main compressional stress (σ_1) direction responsible for folding is 29°, N200°E and the minimum stress (σ_3) is 59°, N010°E (**Fig 12**). Hence, the structure can be classified as a steeply inclined gently plunging anticline with a close interlimb angle of ~62 ° (Fleuty, 1964 in Fossen, 2010).

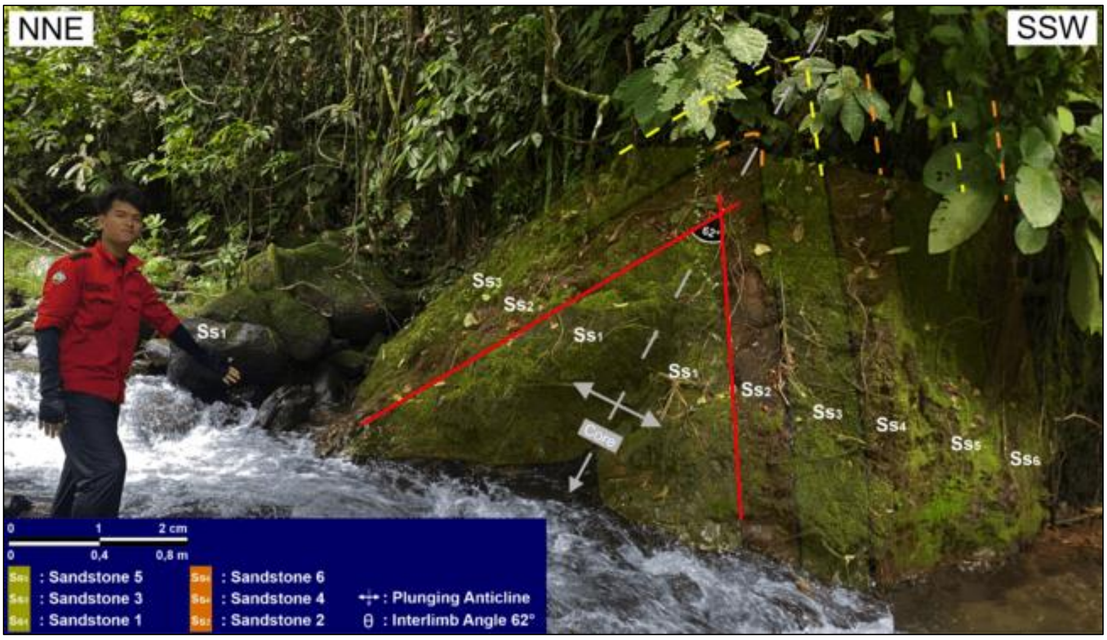

Fig 11. An asymmetrical plunging anticline exposed at the Air Kenidian river showing an angular hinge surface interpreted as a plunging asymmetrical kink fold or kink band; Ss_1, Ss_3, and Ss_5: medium grain-sized sandstones; Ss_2, Ss_4, and Ss_6: fine grain-sized sandstones.

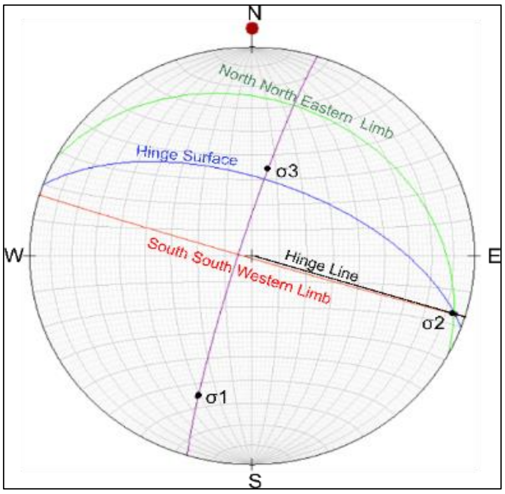

Fig 12. Stereographic Analysis of the Air Kenidian Anticline.

4.6 Air Kenidian Syncline

This fold is exposed at the northeastern portion of the study area and trends to NW-SE or N140°E. Deformation has involved the sandstone units of the Seblat Formation and formed a synformal structure with the measured dips of the NE limb 18° and the SW limb 25°, suggesting a symmetrical syncline (**Fig. 13**). This syncline shows an angular hinge surface thus the structure is a kink fold (Fossen, 2010; Hudleston, 1986; Richard, 2004). In contrast to the respective asymmetrical kink band, the Air Kenidian syncline is a symmetrical kink fold or chevron.

The result of stereographic analysis reveals that the main stress (σ_1) direction responsible for folding is 06°, N050°E and the minimum stress (σ_3) is 84°, N230°E (**Fig 14**). The measured structural elements in this particular site suggest that the folding structure can be classified as an upright horizontal fold with a gentle interlimb angle of 137° (Fleuty, 1964 in Fossen, 2010)

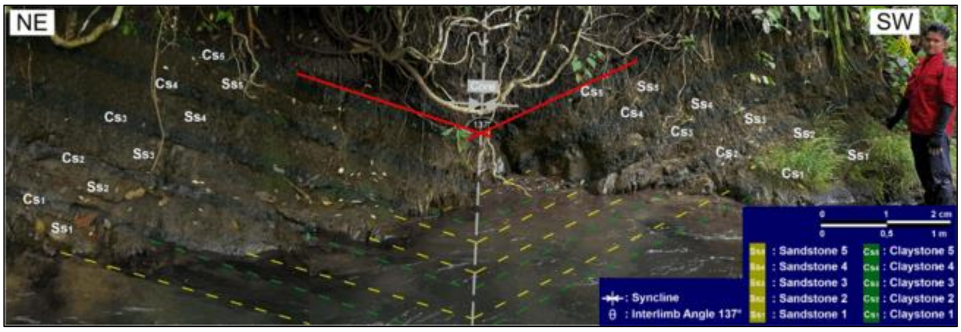

Fig 13. The structural outcrop at the Air Kenidian river showing a symmetrical syncline with an angular hinge surface interpreted as symmetrical kink folding or chevron.

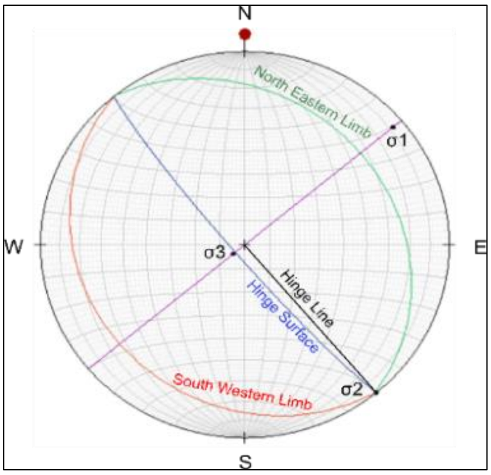

Fig 14. Stereographic Analysis of the Air Kenidian Syncline.

4.7 Air Selali Kecil Fault

This fault is exposed to the southwest of the study area and strikes to NE-SW or N115°E. The faulting resulted in a rock bedding offset and a fracture plane with slickensides on the footwall (Fw) stepping to NW, suggesting a thrust fault. Thrusting appeared to have displaced the sandstone unit of the Simpangaur Formation (**Fig 15**). According to Woodcock and Mort (2008), the thrust fault shows a fault breccia with a length of around 18.5 cm and a height of 4.5 cm.

Analysis using a stereographic diagram reveals that the main stress (σ_1) direction responsible for thrusting is 28°, N056°E and the minimum stress (σ_3) is 58°, N264°E (**Fig 16**). Importantly, the measured structural components in this particular area suggest that the structure is horizontal dip-slip faulting (Fossen, 2010).

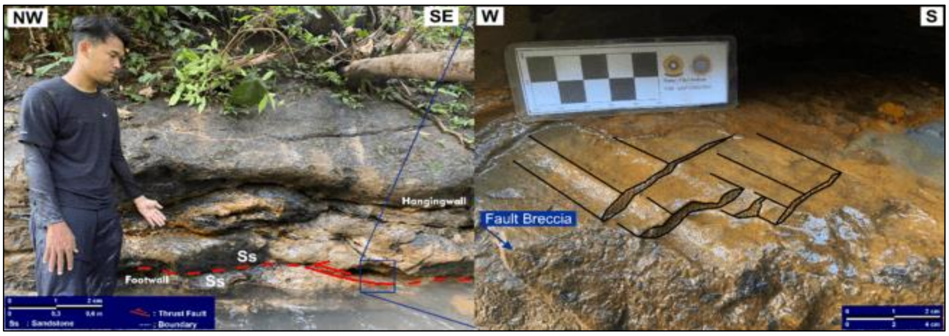

Fig 15. The outcropping structure at Air Selali Kecil river showing a thrust fault (left). Also shown the recorded slickensides on the footwall block stepping to NW (right).

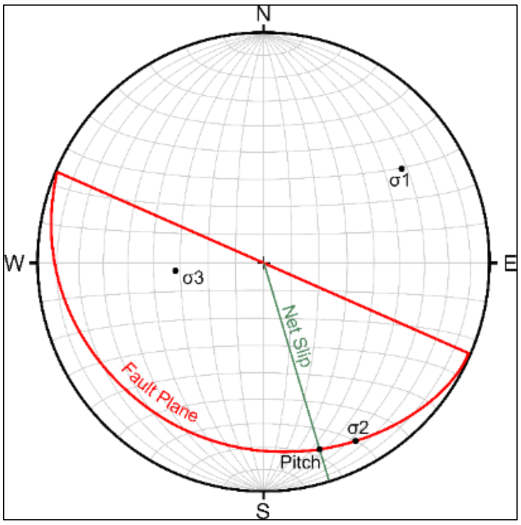

Fig 16. Stereographic Analysis of the Air Selali Kecil Fault.

5. Discussion

Analysis of field structural data in the recent study reveals that there existed two regimes of tectonic stresses responsible for rock deformation, transtension and transpression. The brittle-typed structuring due mainly to transtension was encountered in the Tanjungaur region. These include listric extensional faults in the Tanjung Aur II-A, -B, and -D, and domino extensional fault in the Tanjung Aur II-C. It has been recognized that the listric extensional faulting generally trends to NE-SW, suggesting the WNW-directed rifting commenced in Paleocene-Eocene time. The event formed a graben system within the basin.

Fig. 17 displays a structural map that was constructed on the basis of the field data compiled with the DEM interpretation. The map depicts two general-trending structural landforms, the NE-SW tensional configurations are represented predominantly by listric extensional faults, and the NW-SE compressional features include the folding and thrusting. Additionally, the NE-SW extensional trend implies that rifting of the basin as well as deposition of the sedimentary materials during Paleogene were likely progressing towards the WNW direction. However, the NW-SE compressional structures suggest that the sedimentary rock sequence within the basin underwent the NE-SW tectonic transport, probably associated with the uplift of Bukit Barisan orogenic belt in the Late Neogene or Plio-Pleistocene time (Hall, 2014; Simandjuntak and Barber, 1996). Herein, the Late Neogene orogeny is considered as the last tectonic event responsible for the inversion of the Bengkulu basin, consequently the deformation of rock successions prior to the resulted structures were exposed to the surface due principally to erosional denudation.

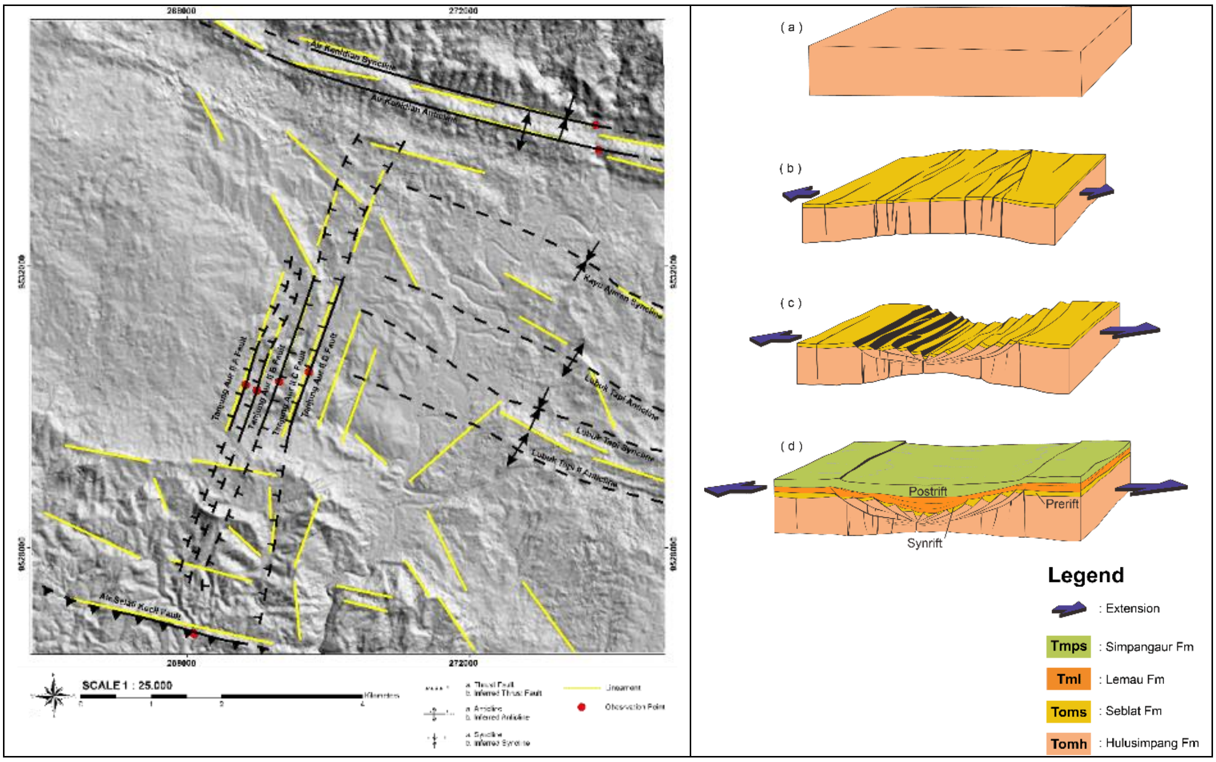

Fig 17. The map displaying structural trends generated from integration of field data and DEM interpretation (left); also shown 3D models depicting the conceptual development of rifting responsible for graben formation (right).

6. Conclusions

The present work reveals that there are at least two tectonic episodes responsible for the evolution of the Bengkulu Basin, which led to the synrift and post-rift deformations. The synrift tectonic event due mainly to extensional stresses, which resulted in the Tanjung Aur II-A, B, and D listric faults, and the Tanjung Aur II-C domino faults. The early deformation of the basin may take place following the commencement of graben formation in the Paleogene or Paleocen-Eocene time. Whereas, the post-rift tectonic event was mainly controlled by a compressional regime that produced the Air Kenidian asymmetrical anticline, the Air Kenidian symmetrical syncline, and the Air Selali Kecil thrust fault. The later deformation of the basin may occur in the Late Neogene or Plio-Pleistocene time, coincident with the uplift of Bukit Barisan orogenic belt.

Acknowledgements

The authors would like to thank the Coordinator of Geology Study Program, Faculty of Engineering, Sriwijaya University for allowing us to publish the results of our recent research on tectonic structures. The Head of Geological Laboratories in the study program are also thanked for giving us permission to use facilities during petrographic and paleontological analyses and structural modelling.

References

Barber, A. J., and Crow, M. J. 2003. An Evaluation of Plate Tectonic Models for the Development of Sumatra. Gondwana Research, 6(1), 1–28. https://doi.org/10.1016/S1342-937X(05)70642-0

Daly, M. C., Cooper, M. A., Wilson, I., Smith, D.G., and Hooper, B. G. D. 1991. Cenozoic Plate Tectonics and Basin Evolution in Indonesia. 8, 2–21.

Fajri, S. N., Surtiyono, E., and Nalendra, S. 2019. Lineament Analysis of Digital Elevation Model to Identification of Geological Structure in Northern Manna Sub-Basin, Bengkulu. IOP Conference Series: Materials Science and Engineering, 636(1). https://doi.org/10.1088/1757-899X/636/1/012001

Fleuty, M. J. 1964. The Description of Folds. Proceedings of the Geologist Association.

Fossen, H. 2010. Structural Geology. Cambridge University Press.

Hall, R. 2014. The Origin of Sundaland. Proceedings of Sundaland Resources 2014 MGEI Annual Convention, November, 1–26.

Hidayatillah, A. S., Nurcahyo, T. A., Muliawan, J. B. P., and Endarsih, A. E. 2024. Identifying Dominant Structural Pattern of Semarang City Using Digital Elevation Model and Landsat 8-OLI Imagery. Journal of Geoscience, Engineering, Environment, and Technology, 9(1), 28–37. https://doi.org/10.25299/jgeet.2024.9.1.12706

Howles, A. C. 1984. Structural and Stratigraphic Evolution of the Southwest Sumatran Bengkulu Shelf. 1984. https://doi.org/10.29118/ipa.2123.215.243

Hudleston, P. J. 1986. Extracting Information From Folds in Rocks. Journal of Geological Education, 34(4), 237–245. https://doi.org/10.5408/0022-1368-34.4.237

Kusnama, K., Mangga, S. A., and Sukarna, D. 1993. Tertiary Stratigraphy and Tectonic Evolution of Southern Sumatra. Bulletin of the Geological Society of Malaysia, 33, 143–152. https://doi.org/10.7186/bgsm3319931

McClay, K. 1988. The Mapping of Geological Structures. London: Department of Geology Royal Holloway and Bedford New College, University of London. https://doi.org/10.1080/00288306.1988.10422149

Mukti, M. M. 2011. Structural Style and Evolution of the Sumatran Forearc Basins. May. https://doi.org/10.29118/ipa.684.11.g.082

Natawidjaja, D. H. 2010. The Sumatran Fault Zone — from Source to Hazard. Journal of Earthquake and Tsunami, 1, 21–47.

Richard, J. L. 2004. Geological Structures and Maps (Third). British Library Cataloguing in Publication Data.

Seleem, T. A. 2013. Analysis and Tectonic Implication of DEM-Derived Structural Lineaments, Sinai Peninsula, Egypt. International Journal of Geosciences, 04(01), 183–201. https://doi.org/10.4236/ijg.2013.41016

Setiawan, B., and Goestyananda, P. 2022. Control Structure On Damage Zone and Fault Plane to Geometry Of Quartz Veins and Calcite In Muaradua Ogan Komering Ulu Selatan, South Sumatra, Indonesia. Journal of Geoscience, Engineering, Environment, and Technology, 7(4), 196–205. https://doi.org/10.25299/jgeet.2022.7.4.9411.

Sieh, K., and Natawidjaja, D. 2000. Neotectonics of the Sumatran Fault, Indonesia. Journal of Geophysical Research: Solid Earth, 105(B12), 28295–28326. https://doi.org/10.1029/2000jb900120

Simandjuntak, T. O., and Barber, A. J. 1996. Contrasting Tectonic Styles in the Neogene Orogenic Belts of Indonesia. Geological Society Special Publication, 106(106), 185–201. https://doi.org/10.1144/GSL.SP.1996.106.01.12

Syahputra, R., Sihombing, F. M. H., and Prasojo, O. A. 2019. Correlation Between Fracture Azimuth, Surface Lineaments and Regional Tectonics: A case study from Belik District, Central Java, Indonesia. Journal of Geoscience, Engineering, Environment, and Technology, 4(1), 22. https://doi.org/10.25299/jgeet.2019.4.1.2294

Woodcock, N. H., and Mort, K. 2008. Classification of Fault Breccias and Related Fault Rocks. Geological Magazine, 145(3), 435–440. https://doi.org/10.1017/S0016756808004883

Yulihanto, B., Situmorang, B., Nurdjajadi, A., and Sain, B. 1995. Structural Analysis of the Onshore Bengkulu Forearc. Proceedings, Indonesian Petroleum Association 24, October 1995, 85–96.

Zuhri, W., and Sutriyono, E. 2020. Late Neogene Deformation of Rock Successions at Renah Gajah Mati I Region, Seluma Regency in Bengkulu. Jurnal Teknologi, 82(2), 77–83. https://doi.org/10.11113/jt.v82.13510