JPPIPA 11(8) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Characterization of Subsurface Structure Using Gravity Data Inversion in the Ombilin Basin, West Sumatra

Fitria[1], A. Haris[2*], Rinaldo[1]

[1] Master Program in Reservoir Geophysics, Department of Physics, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Indonesia, Depok, Indonesia.
[2] Geology and Geophysics Study Program, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Indonesia, Depok, Indonesia.

Received: May 15, 2025
Revised: July 18, 2025
Accepted: August 25, 2025
Published: August 31, 2025

Corresponding Author:
A. Haris
aharis@sci.ui.ac.id

DOI: 10.29303/jppipa.v11i8.11762

© 2025 The Authors. This open access article is distributed under a (CC-BY License)

Abstract: The Ombilin Basin in West Sumatra is one of the oldest intermontane basins in Indonesia that has significant geological potential, especially in relation to coal content and possible petroleum systems. This study uses a three-dimensional gravity inversion method to model the distribution of subsurface density from a depth of 0 to 6000 meters. The purpose of this study is to examine the subsurface geological modeling in the Ombilin Basin and to be a reference in exploration geophysical studies in other basins in Indonesia that have similar characteristics. Corrected regional gravity data are used as input in the inversion process to reconstruct the relative density model of rocks. The inversion results show a low-density zone (Δg between -0.1995 to -0.0099 gr/cc) in the central and southwest parts of the basin associated with sedimentary deposits such as sandstone, shale, and coal. At depths of more than 4000 meters, a high-density zone is identified that reflects the presence of basement rocks or possible magmatic intrusions. This density distribution strengthens the understanding of the basin geometry and potential hydrocarbon traps. This study shows that the gravity inversion method is an effective and economical approach for subsurface geological interpretation, especially in areas with limited exploration data.

Keywords: Basement; Geophysical methods; Gravity inversion; Ombilin Basin; Subsurface density

Introduction

The Ombilin Basin is one of the oldest intermontane basins in Indonesia located in West Sumatra. This basin was formed as a result of intensive tectonic activity during the Tertiary period and is widely known for its abundant coal content and complex geological history. Knowledge of the subsurface structure of this basin is very important, not only in the context of natural resource exploration such as coal and hydrocarbons, but also to understand the tectonic dynamics of the western Sumatra region (Zonneveld et al., 2025; Chen et al., 2015). Strain on the outermost curve (extrados) of the Sunda Orocline (the direction of relative motion is indicated by the red arrow) during the Paleogene rotation caused the formation of a sedimentary basin (Incerti et al., 2025; Yuan et al., 2022).

The Sumatra Fault System is only dominated by one shear fault zone that has been active since the late Neogene, which caused the formation of several grabens. The formation process of this Transtensional can be divided into 3 main phases including: D1: First phase At pre-Tertiary age where this phase was formed by strong north-south compression due to the subduction of the Indian-Australian ocean plate under the Sunda shelf, thus forming a series of normal faults that caused the formation of the Payakumbuh Sub Basin and the Ombilin Basin depocenter; D2: The second phase of tectonism occurred from the Late Eocene to the Early Miocene and experienced a shift in the direction of compression from north-south to northeast-southwest; D2 is characterized by the breakup of the Ombilin Basin into 2 sub-basins, namely the Talawi Sub-basin and the Sinamar Sub-basin; D3: The third and final phase of

How to Cite:
Fitria, Haris, A., & Rinaldo. (2025). Characterization of Subsurface Structure Using Gravity Data Inversion in the Ombilin Basin, West Sumatra. *Jurnal Penelitian Pendidikan IPA*, *11*(8), 593–600. https://doi.org/10.29303/jppipa.v11i8.11762

deformation from the Late Miocene to the Pliocene characterizes the closure of the Ombilin and Payakumbuh Basins due to continuous compression from the northeast-southwest. Which resulted in increasing folding intensity. Geophysical methods, especially the gravity method, have proven to be one of the efficient and economical approaches in identifying variations in subsurface rock density (Omolaiye et al., 2024; Abdelfattah, 2024).

Gravity field measurements allow for indirect interpretation of geological structures, especially in areas with limited seismic or well data (Eshagh, 2021; Harms, 2015). However, raw gravity data only provide a one-dimensional picture (Izvoltova et al., 2022; Karaiskos et al., 2024). Therefore, the inversion process is the main key in reconstructing a three-dimensional density distribution model from gravity field anomaly data. Gravity inversion allows estimation of the relative density distribution of subsurface rocks by minimizing the difference between measured gravity anomalies and simulation models (Y. Li & Oldenburg, 1998; Yasmin et al., 2024; Setiahadiwibowo et al., 2025). In the context of sedimentary basins such as Ombilin, gravity inversion is useful for identifying the boundary between low-density porous sedimentary rocks and dense basement rocks at greater depths. The density distribution obtained from the inversion provides important information about the basin geometry, potential structural traps, and the location of basement intrusions or uplifts (P. Li et al., 2021).

Previous studies in the Sumatra region have shown the effectiveness of this method in revealing complex geological structures in areas dominated by active tectonic activity. For example, De Lima et al. (2023), Yan et al. (2021) and Deng et al. (2025), used gravity inversion to trace the lithospheric boundary and crustal structure along Sumatra, which can be relevantly applied in Ombilin. In addition, Martins et al. (2019), emphasized that the combination of gravity data with local geological models can improve the resolution of interpretation (Ramdani et al., 2024; Thanh Pham et al., 2021), especially in closed basins with large sediment thicknesses. In this study, a 2D gravity inversion approach was used to interpret the subsurface density distribution in the Ombilin Basin from surface depth (0 meters) to 6000 meters.

The inversion results show that low-density zones are predominantly distributed in the central and southwest parts of the basin, reflecting the filling by porous sedimentary rocks such as sandstone, shale, and coal. Meanwhile, at depths of more than 4000 meters, higher density zones associated with Pre-Tertiary basement rocks or igneous intrusions are identified. Understanding this density distribution pattern is crucial for identifying potential hydrocarbon traps, interpreting petroleum systems, and modeling the overall evolution of the basin. With this approach, this study is expected to contribute to subsurface geological modeling in the Ombilin Basin and become a reference in exploration geophysical studies in other basins in Indonesia that have similar characteristics.

Method

The Ombilin Basin is 60 km long and 25 km wide. In the north, this basin is bordered by the Payakumbuh area, while in the south it is bordered by the Solok area. There are two major events that play a role in the formation of this basin and are seen in its sedimentation model, namely tectonism and magmatism. This study uses a three-dimensional gravity data inversion method to estimate the distribution of subsurface density in the Ombilin Basin, West Sumatra. The data used are regional gravity data that have been corrected with drift, tidal, latitude, free-air, and terrain corrections to produce complete Bouguer anomalies. Residual anomalies are calculated by separating regional and local components using a low-order polynomial approach. The inversion process is carried out using a regularized least-squares approach to solve linear problems with smoothness regularization, in a 3D voxel grid domain up to a depth of 6000 meters. The initial model is assumed to be homogeneous and inversion is performed iteratively to minimize the difference between observed and synthetic anomalies. The inversion results are visualized in the form of vertical slices at several depths and analyzed to identify low and high density distribution patterns related to the geological structure of the basin and the potential for sediment filling. Interpretation is carried out by considering regional geological conditions, especially the presence of Pre-Tertiary sedimentary and basement rocks in the Ombilin basin area (Wang et al., 2023).

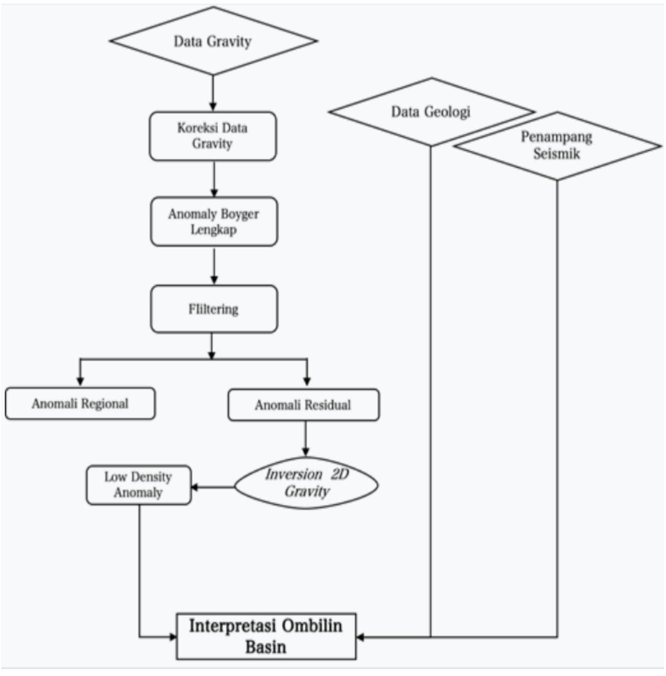

Figure 1. Research flow diagram

Result and Discussion

Ombilin is a graben formed by a pull-apart structure produced during the Early Tertiary period, the study also produced geological mapping that provides information that recent oil and gas exploration shows that the Ombilin Basin is a basin filled with Early Tertiary sedimentary layers, flanked by pre-Tertiary Bukit Barisan rocks from the east and west (Hastuti, 2017; Idarwati et al., 2025; Adrianda et al., 2025). Structural relationship between the Sunda Orocline structure (red dashed line) and the Sumatra Fault System (solid yellow line).

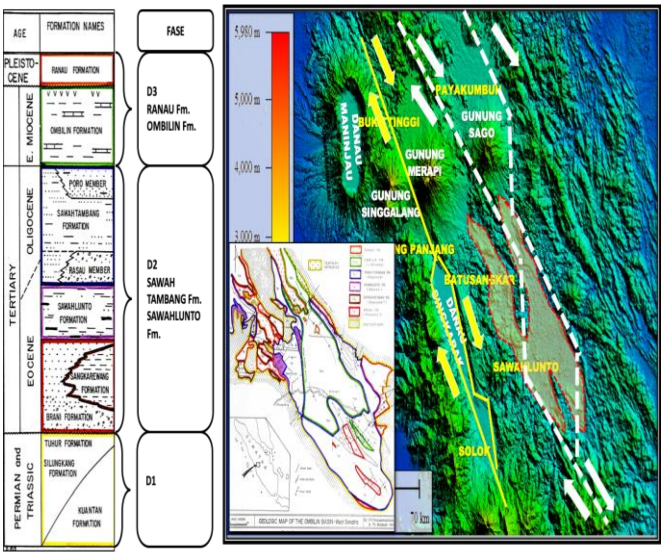

Figure 2. Geology map of Ombilin Basin

Bouguer Anomaly Complete

The gravity data obtained is complete bouger anomaly data that has been corrected, where the gravity anomaly value ranges from -26 to 28 mgal. Especially for the Ombilin Basin area, the anomaly value looks low, which is around -26 to 5 mGal.

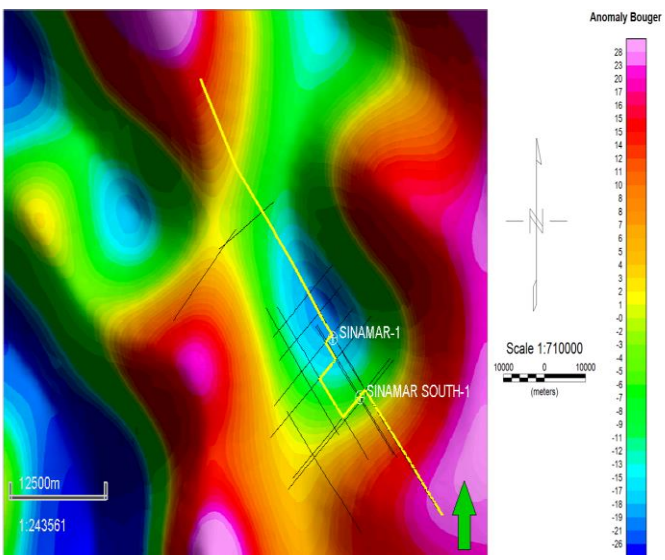

Figure 3. Complete bouger anomaly map

Filtering Map

The separation of regional and residual anomalies in this study is by using a Bandpass Filter, which aims to eliminate the Regional influence (low-pass) in the Ombilin Basin, as well as eliminate local or instrumental noise (high-pass). The Long wavelength cutoff value of 50,000 has been applied, and the short wavelength cutoff of 3800, so that the gravity value of the residual anomaly ranges from -11 to 5 mGal.

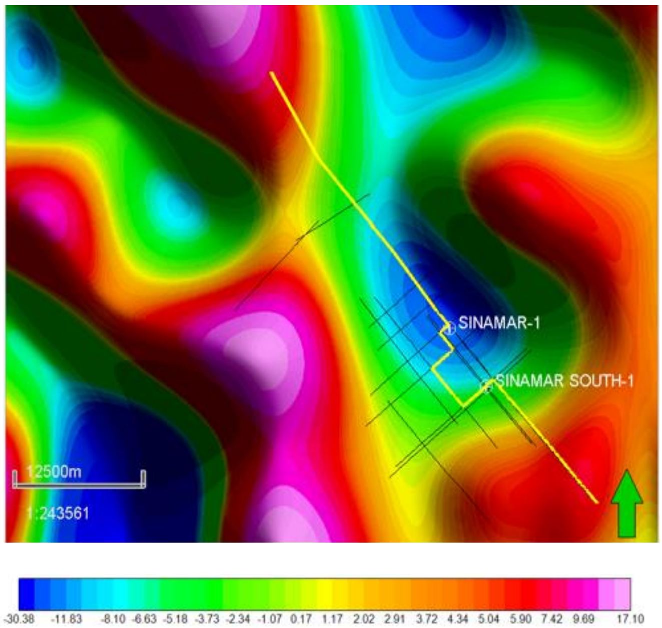

Figure 4. Gravity map after bandpass filter

Focus 2D gravity inversion is performed on the F trajectory with quite significant gravity value anomalies.

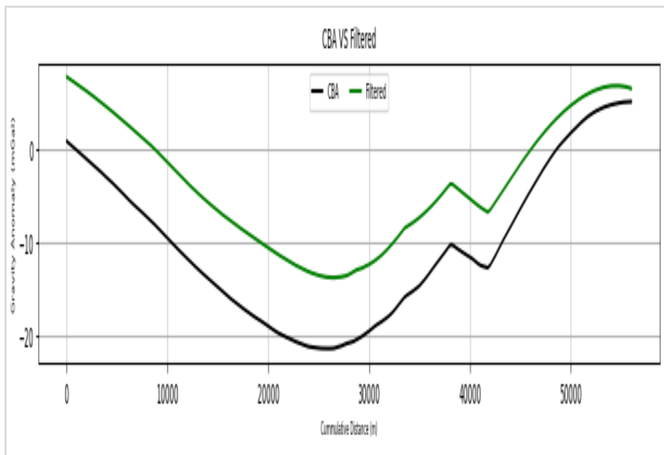

Figure 5. Comparison of CBA and bandpass filter graphs

Inversion Results

The inversion results on trajectory F show a fairly low misfit value, this can be seen in the observation data graph with the calculation result graph which has almost the same value. Low density values are seen at shallow depths of around 0 to 1000 m, but curve further in the middle of the trajectory.

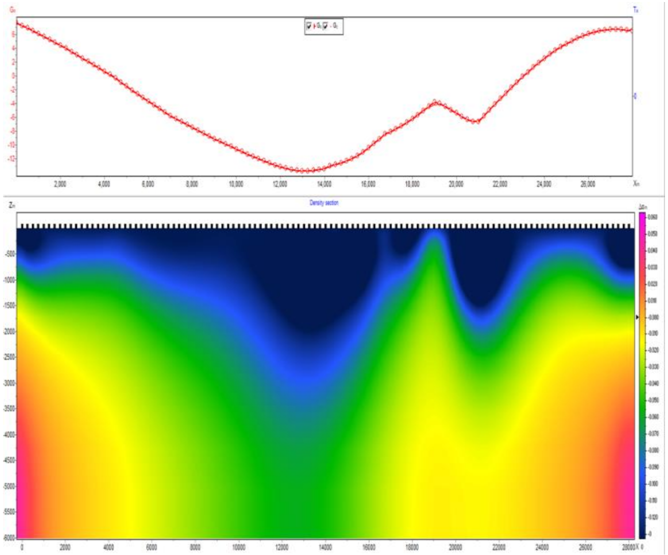

Figure 6. Inversion results on trajectory F

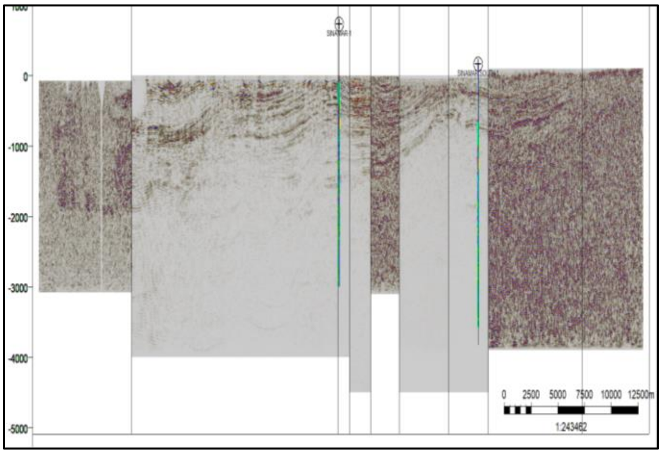

Figure 7. Seismic cross-section on line F

The reflector is clearly visible and continuous on the seismic cross-section of Line F at a depth of 1500-2000 m. The seismic reflector appears to decrease or is faint in the middle of the line at a depth of around 2000 – 3000, and is unclear at depths above 3000 m.

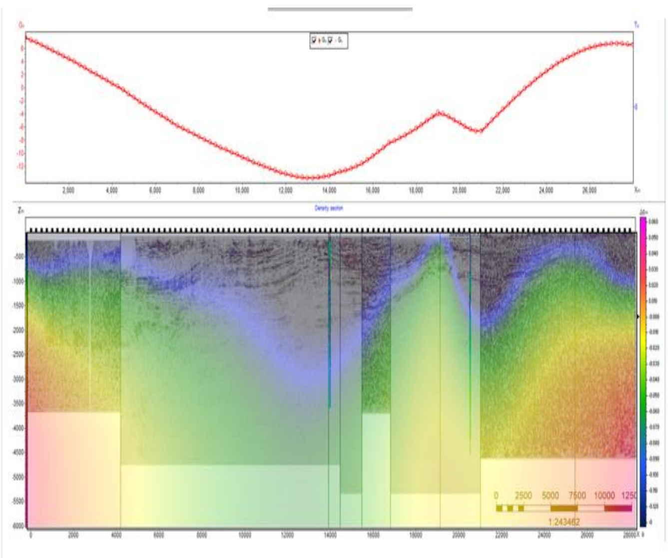

Figure 8. Seismic cross-section on line F

The seismic cross-section shows a clear reflector at a depth of 1500-2000 m, with low density distribution data in the zone ranging from -0.1995 to -0.0745 gr/cc. The seismic reflector at a depth of 2000 to 3000 does not look very continuous or clear, with a density value (around -0.0298 to 0.0104 gr/cc).

Density Distribution

The depth slice map of gravity inversion results at a depth of 1000 meters in the Ombilin Basin area shows a distribution of Δg values that are entirely in the negative range, namely between -0.1995 to -0.0745 gr/cc. This range indicates that the entire zone at this depth is dominated by low-density material, with no indication of high-density rocks such as igneous rocks or basement rocks. The anomalous zone with the lowest Δg value (dark blue) is concentrated in the central to southeastern part of the map and extends southward (Li, 2025; Ligi et al., 2022), indicating the possibility of thick sediment deposition such as claystone or coal from the Sawahlunto and Sangkarewang Formations which are indeed common in the center of the basin. This even distribution of low density strengthens the interpretation that the area is still in the basin filling zone, and has not reached the depth where the basement rock is exposed. The elongated pattern of low gravity anomalies can also reflect the presence of geological structures such as grabens or dip faults, which are the main routes of thick sediment deposition (Balkan & Tün, 2023; Tillmans et al., 2021).

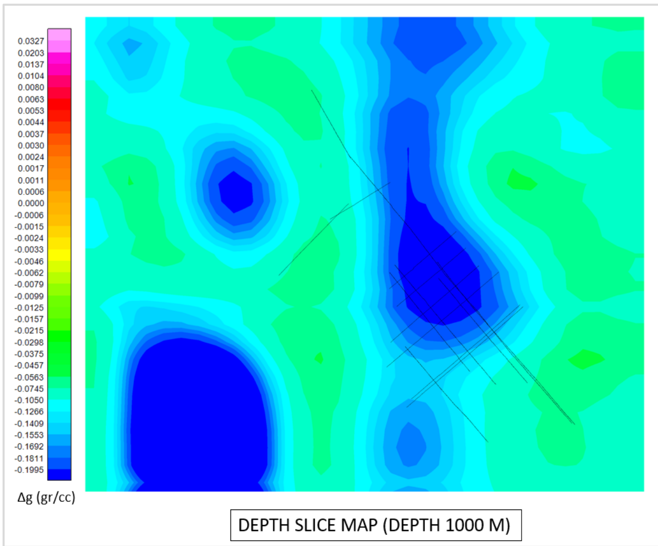

Figure 9. Depth slice map of gravity inversion results at a depth of 1000 meters

The depth slice map of gravity inversion results at a depth of 3000 meters in the Ombilin Basin area shows significant changes in density distribution. At this depth, zones with Δg values approaching zero to mildly positive (around -0.0298 to 0.0104 gr/cc) begin to appear, indicated by a gradation of green to yellow and orange. This indicates that the rocks at this depth have a higher density than the layers above them, which is most likely a transition from sedimentary rocks to more compact rocks, or even approaching the basement of the basin. The light blue zone in the middle of the map that still reflects mildly negative Δg values indicates the presence of remnants of medium-porosity sediments (Sun et al., 2025), but in general, this area shows a dominance of rocks with denser physical characteristics. The distribution of positive anomalies that began to develop, especially in the northern and western parts of the map (Ariska et al., 2024; Nicholson et al., 2018), indicates that the basement began to be identified, consistent with the regional geological model in which the basement of the Ombilin Basin is quite shallow at the edge of the basin and deepens towards the center. This change in anomaly value is in line with the geological structure of the Ombilin Basin which is in the form of a graben, where the center is a subsidence zone filled with Paleogene sediments, while the sides are bounded by faults and flanked by older and denser Pre-Tertiary rocks.

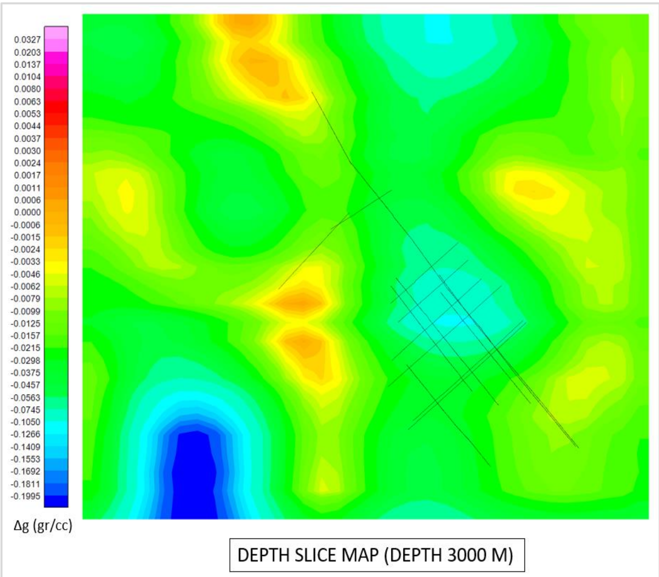

Figure 10. Depth slice map of gravity inversion results at a depth of 3000 meters

The gravity inversion slice map at a depth of 6000 meters in the Ombilin Basin area shows a very clear dominance of positive gravity anomalies, with Δg values reaching a range of 0.0006 to more than 0.0327 gr/cc. The widespread dark red to pink color, especially in the central and southern parts of the map, indicates the presence of very high-density rocks associated with the Pre-Tertiary basement underlying the entire basin (Fosso Menkem et al., 2024; Robertson et al., 2020; J. Chen et al., 2022). The existence of these high anomaly zones indicates that at this depth, the basin-filling sediments are no longer developing and the entire volume of space is likely occupied by massive basement rocks (Pohan et al., 2023; Ekwok et al., 2022; Kaban et al., 2021). These characteristics are very consistent with the geological character of the Ombilin Basin, which is an old intermontane basin, surrounded by metamorphic and igneous rocks that have been uplifted as a result of intensive tectonic activity. The sharp decrease from negative anomalies at shallow depths to a predominance of positive anomalies at 6000 m reflects the vertical transition from porous and light sedimentary layers to dense non-porous basement rocks. Structurally, these positive anomalies may also represent the presence of complex basement structures such as horsts, deep thrust faults, or potential magmatic intrusions (Masror et al., 2025; Issatayeva et al., 2025; Eze et al., 2024).

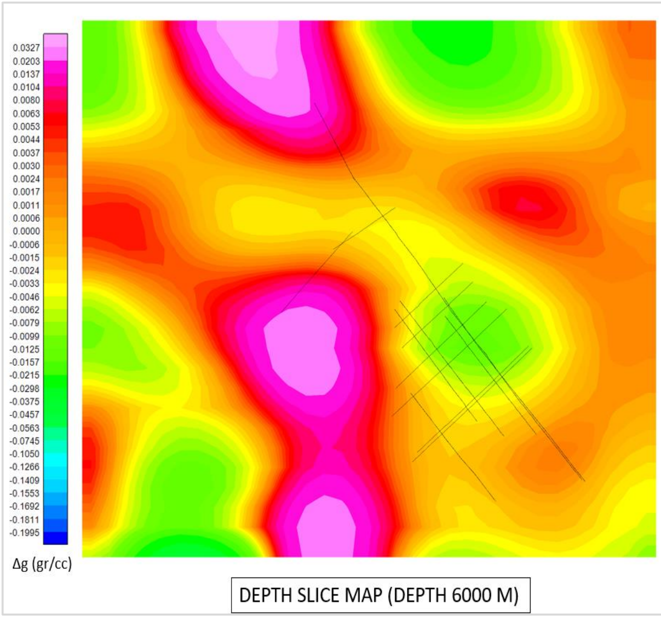

Figure 11. Depth slice map of gravity inversion results at a depth of 6000 meters

Conclusion

The results of three-dimensional gravity data inversion in the Ombilin Basin successfully revealed the distribution pattern of subsurface density from a depth of 0 to 6000 meters. Low-density zones with a range of values between -0.1995 to -0.0099 were predominantly found in the central and southwest parts of the basin, which were interpreted as filling sedimentary rocks such as sandstone, shale, and coal. Meanwhile, at a depth of more than 4000 meters, relatively higher density zones associated with basement rocks or magmatic intrusions began to be identified. This density distribution reflects the geological architecture of the Ombilin Basin which is controlled by tectonic processes and intermontane sedimentation. Thus, the gravity inversion method has proven effective in mapping variations in density and subsurface structures non-invasively, and can be used as an initial basis for geological resource exploration in similar basins.

Acknowledgments
Thank you to University of Indonesia.

Author Contributions
Conceptualization, F.; methodology, A. H.; validation, R.; formal analysis, F.; investigation, A. H.; resources, R.; data curation, F.: writing—original draft preparation, A. H.; writing—review and editing, R.; visualization. All authors have read and agreed to the published version of the manuscript.

Funding
Researchers independently funded this research.

Conflicts of Interest
No conflict interest.

References

Abdelfattah, M. D. (2024). An automatic new approach to gravity anomaly's profile separation, inversion and interpretation, using an infinite horizontal slab model. *NRIAG Journal of Astronomy and Geophysics*, *13*(1), 118–140. https://doi.org/10.1080/20909977.2024.2368959

Adrianda, R. S., Sahara, R., & Gusti, U. K. (2025). The geodiversity site of Geopark Ranah Minang Silokek, Indonesia: Promoting geo-education and geotourism through geosite assessment. *International Journal of Geoheritage and Parks*, *13*(2), 239–249. https://doi.org/10.1016/j.ijgeop.2024.11.012

Ariska, M., Suhadi, Supari, Irfan, M., & Iskandar, I. (2024). Spatio-Temporal Variations of Indonesian Rainfall and Their Links to Indo-Pacific Modes. *Atmosphere*, *15*(9), 1036. https://doi.org/10.3390/atmos15091036

Balkan, E., & Tün, M. (2023). Use of Land Gravity Data in Small Areas to Support Structural Geology, a Case Study in Eskişehir Basin, Turkey. *Applied Sciences*, *13*(4), 2286. https://doi.org/10.3390/app13042286

Chen, G., Liu, T., Sun, J., Cheng, Q., Sahoo, B., Zhang, Z., & Zhang, H. (2015). Gravity method for investigating the geological structures associated with W–Sn polymetallic deposits in the Nanling Range, China. *Journal of Applied Geophysics*, *120*, 14–25. https://doi.org/10.1016/j.jappgeo.2015.06.001

Chen, J., Cazenave, A., Dahle, C., Llovel, W., Panet, I., Pfeffer, J., & Moreira, L. (2022). Applications and Challenges of GRACE and GRACE Follow-On Satellite Gravimetry. *Surveys in Geophysics*, *43*(1), 305–345. https://doi.org/10.1007/s10712-021-09685-x

De Lima, D. P. D., Carmelo, A. C., Soares, J. E. P., De Lima, M. V. A. G., & Fuck, R. A. (2023). Gravity inversion for crustal thickness investigation of the continental and oceanic crusts of Brazil incorporating a lithosphere thermal gravity anomaly correction. *Tectonophysics*, *846*, 229663. https://doi.org/10.1016/j.tecto.2022.229663

Deng, Q., Ye, M., Hao, W., Xiao, C., Zhong, Z., Qiu, D., Zhang, W., Zheng, C., Wang, Y., Yan, J., Barriot, J.-P., Xiao, Z., & Li, F. (2025). Crustal thickness and lithospheric properties of Mercury constrained by gravity data. *Geo-Spatial Information Science*, 1–25. https://doi.org/10.1080/10095020.2025.2511975

Ekwok, S. E., Achadu, O.-I. M., Akpan, A. E., Eldosouky, A. M., Ufuafuonye, C. H., Abdelrahman, K., & Gómez-Ortiz, D. (2022). Depth Estimation of Sedimentary Sections and Basement Rocks in the Bornu Basin, Northeast Nigeria Using High-Resolution Airborne Magnetic Data. *Minerals*, *12*(3), 285. https://doi.org/10.3390/min12030285

Eshagh, M. (2021). The Earth's Gravity Field Role in Geodesy and Large-Scale Geophysics. In *Geodetic Sciences—Theory, Applications and Recent Developments*. IntechOpen. https://doi.org/10.5772/intechopen.97459

Eze, O. E., Okiwelu, A. A., Ekwok, S. E., Abdelrahman, K., Alzahrani, H., Ben, U. C., Ibrahim, A., Akpa, C., Andráš, P., Ugar, S. I., & Eldosouky, A. M. (2024). Delineation of deep-seated crustal structures from magnetic data in the southeastern part of the Niger Delta basin, Nigeria. *Frontiers in Earth Science*, *12*, 1439199. https://doi.org/10.3389/feart.2024.1439199

Fosso Menkem, E., Ngounou Ngatcha, B., Ngong Ngia, R., Fuanya, C., & Ekodeck, G. E. (2024). Tectonic and sedimentary evolution of the Northern Cameroon Cretaceous rift basins: A study of the Babouri-Figuil and Mayo Oulo-Lere basins. *Geosystems and Geoenvironment*, *3*(3), 100291. https://doi.org/10.1016/j.geogeo.2024.100291

Harms, J. (2015). Terrestrial Gravity Fluctuations. *Living Reviews in Relativity*, *18*(1), 3. https://doi.org/10.1007/lrr-2015-3

Hastuti, E. W. D. (2017). Geochemical study of pyroclastic rocks in Maninjau Lake, West Sumatra. *IOP Conference Series: Earth and Environmental Science*, *71*, 012034. https://doi.org/10.1088/1755-1315/71/1/012034

Idarwati, Setiawan, B., Jati, S. N., Rochmana, Y. Z., Mayasari, E. D., & Rendana, M. (2025). Schematic formation of boudine granite and microfold phyllite of Gilas River: Implications for Triassic to Tertiary tectonics of Garba Hill, South Ogan Komering Ulu Regency, South Sumatra Province. *Geosystems and Geoenvironment*, *4*(3), 100414. https://doi.org/10.1016/j.geogeo.2025.100414

Incerti, A., Rinaldini, V., Santandrea, M., Carloni, C., & Mazzotti, C. (2025). Effect of Density and Number of Layers of Fiber Sheets and End Anchors on the Flexural Capacity of SRG-Strengthened RC Beams. *Buildings*, *15*(7), 1005. https://doi.org/10.3390/buildings15071005

Issatayeva, F., Abetov, A., Umirova, G., Abdullina, A., Mustafin, Z., & Karpenko, O. (2025). The Roles of Transcrustal Magma- and Fluid-Conducting Faults in the Formation of Mineral Deposits. *Geosciences*, *15*(6), 190. https://doi.org/10.3390/geosciences15060190

Izvoltova, J., Bacova, D., Chromcak, J., & Hodas, S. (2022). Preprocessing of Gravity Data. *Computation*, *10*(6), 82. https://doi.org/10.3390/computation10060082

Kaban, M. K., Gvishiani, A., Sidorov, R., Oshchenko, A., & Krasnoperov, R. I. (2021). Structure and Density of Sedimentary Basins in the Southern Part of the East-European Platform and Surrounding Area. *Applied Sciences*, *11*(2), 512. https://doi.org/10.3390/app11020512

Karaiskos, D., Apostolopoulos, G., & Orfanos, C. (2024). Gravity Survey for Mineral Exploration in Gerolekas Bauxite Mining Site in Greece. *Mining*, *5*(1), 3. https://doi.org/10.3390/mining5010003

Li, P., Huang, G.-C. D., & Savvaidis, A. (2021). Seismic features of the Permian Basin Region from receiver function analysis. *Tectonophysics*, *801*, 228718. https://doi.org/10.1016/j.tecto.2021.228718

Li, W. (2025). Perspective Chapter: Research on Earthquake Disasters Based on Physical Constraints of Computational Gravimetry. In *Earth Sciences* (Vol. 5). IntechOpen. https://doi.org/10.5772/intechopen.1008859

Li, Y., & Oldenburg, D. W. (1998). 3-D inversion of gravity data. *Geophysics*, *63*(1), 109–119. https://doi.org/10.1190/1.1444302

Ligi, M., Cuffaro, M., Muccini, F., & Bonatti, E. (2022). Generation and evolution of the oceanic lithosphere in the North Atlantic. *La Rivista Del Nuovo Cimento*, *45*(9), 587–659. https://doi.org/10.1007/s40766-022-00035-0

Martins, G. S., Mohriak, W. U., & Destro, N. (2019). Synrift evaporite deposition and structural characterization of the onshore Alagoas subbasin. *Interpretation*, *7*(4), SH19–SH31. https://doi.org/10.1190/INT-2018-0207.1

Masror, S. Z., Ntarmouchant, A., Elabouyi, M., Bento Dos Santos, T. M., Manar, A., Smaili, M. H., Mali, B., Ntarmouchant, N., El Mahrad, B., Driouch, Y., Cachapuz, P., Catita, T., & Jeddi, E. M. (2025). Subsurface structure of a foreland basin from analysis of gravity and aeromagnetic data: Revealing the basement structure of Gharb Basin, NW Morocco. *Tectonophysics*, *897*, 230622. https://doi.org/10.1016/j.tecto.2025.230622

Nicholson, S. E., Funk, C., & Fink, A. H. (2018). Rainfall over the African continent from the 19th through the 21st century. *Global and Planetary Change*, *165*, 114–127. https://doi.org/10.1016/j.gloplacha.2017.12.014

Omolaiye, G. E., Oniyangi, A. K., Issa, T. A., & Adam, S. B. (2024). Subsurface investigation for pre-foundation study utilizing integrated geophysical and geotechnical methods, UNILORIN campus. *Discover Geoscience*, *2*(1), 101. https://doi.org/10.1007/s44288-024-00103-4

Pohan, A. F., Sismanto, S., Nurcahya, B. E., Lewerissa, R., Koesuma, S., Saputro, S. P., Amukti, R., Saputra, H., & Adhi, M. A. (2023). Utilization and modeling of satellite gravity data for geohazard assessment in the Yogyakarta area of Java Island, Indonesia. *Kuwait Journal of Science*, *50*(4), 499–511. https://doi.org/10.1016/j.kjs.2023.05.016

Ramdani, D., Pahlevi, A., & Muthia Harahap, R. (2024). Optimal Global Gravity Field Model for Calculation of local Gravity and Geoid in Indonesia. *IOP Conference Series: Earth and Environmental Science*, *1418*(1), 012021. https://doi.org/10.1088/1755-1315/1418/1/012021

Robertson, A. H. F., Parlak, O., Kinnaird, T. C., Taslı, K., & Dumitrica, P. (2020). Cambrian-Eocene pre-rift, pulsed rift, passive margin and emplacement processes along the northern margin of the Southern Neotethys: Evidence from the Antalya Complex in the Alanya Window (S Turkey). *Journal of Asian Earth Sciences: X*, *3*, 100026. https://doi.org/10.1016/j.jaesx.2020.100026

Setiahadiwibowo, A. P., Sismanto, Hilyah, A., Anggraeni, L. A., Purwanto, Moh. S., & Sari, C. F. K. (2025). Comparison of Upward Continuation and Moving Average Filters for Satellite Gravity Data in Probolinggo Fault Case Study. *IOP Conference Series: Earth and Environmental Science*, *1486*(1), 012021. https://doi.org/10.1088/1755-1315/1486/1/012021

Sun, M., Yi, H., Zhao, Z., Feng, C., Zhong, G., & Tu, G. (2025). The Sedimentary Distribution and Evolution of Middle Jurassic Reefs and Carbonate Platform on the Middle Low Uplift in the Chaoshan Depression, Northern South China Sea. *Journal of Marine Science and Engineering*, *13*(6), 1025. https://doi.org/10.3390/jmse13061025

Thanh Pham, L., Anh Nguyen, D., Eldosouky, A. M., Abdelrahman, K., Van Vu, T., Al-Otaibi, N., Ibrahim, E., & Kharbish, S. (2021). Subsurface structural mapping from high-resolution gravity data using advanced processing methods. *Journal of King Saud University - Science*, *33*(5), 101488. https://doi.org/10.1016/j.jksus.2021.101488

Tillmans, F., Gawthorpe, R. L., Jackson, C. A. -L., & Rotevatn, A. (2021). Syn-rift sediment gravity flow deposition on a Late Jurassic fault-terraced slope, northern North Sea. *Basin Research*, *33*(3), 1844–1879. https://doi.org/10.1111/bre.12538

Wang, J., Yuan, Y., Chen, J., Zhang, W., Zhang, J., Liang, J., & Zhang, Y. (2023). Geological Conditions and Suitability Evaluation for CO2 Geological Storage in Deep Saline Aquifers of the Beibu Gulf Basin (South China). *Energies*, *16*(5), 2360. https://doi.org/10.3390/en16052360

Yan, J., Lü, Q., Luo, F., Cheng, S., Zhang, K., Zhang, Y., Xu, Y., Zhang, C., Liu, Z., Ruan, S., & Wang, X. (2021). A gravity and magnetic study of lithospheric architecture and structures of South China with implications for the distribution of plutons and mineral systems of the main metallogenic belts. *Journal of Asian Earth Sciences*, *221*, 104938. https://doi.org/10.1016/j.jseaes.2021.104938

Yasmin, H. S., Pirzada, S. J., Sahroni, T. R., Soekarno, H., Pranoto, B., Puspa, A. D., & Alfisah. (2024). 2D Geological Structure Identification in Mount Ciremai Geothermal Area using the GGMplus Data. *IOP Conference Series: Earth and Environmental Science*, *1344*(1), 012017. https://doi.org/10.1088/1755-1315/1344/1/012017

Yuan, J., Luo, L., Zheng, Y., Yu, S., Shi, J., Wang, J., & Shen, J. (2022). Analysis of The Working Performance of Large Curvature Prestressed Concrete Box Girder Bridges. *Materials*, *15*(15), 5414. https://doi.org/10.3390/ma15155414

Zonneveld, J.-P., Barreda, V. D., Zaim, Y., Aswan, Rizal, Y., Hascaryo, A. T., Ciochon, R. L., Head, J., Murray, A., Smith, T., Wilf, P., & Bloch, J. I. (2025). Depositional framework of the Sangkarewang and Sawahlunto Formations, Ombilin Basin, West Sumatra, Indonesia. *Journal of Asian Earth Sciences*, *287*, 106611. https://doi.org/10.1016/j.jseaes.2025.106611