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Seismic Interpretation Using RMS Amplitude and Envelope Attributes to Identify Hydrocarbon Prospects in the "CAT" Field, Central Sumatra Basin

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Abstract

To enhance oil production rates, optimising idle wells with reserve potential and continuing exploration efforts to discover new hydrocarbon resources are necessary. The CAT Field in the Central Sumatra Basin is one of Indonesia's prospective oil and gas-producing areas. This study aims to identify and map the distribution of sandstone reservoirs through 3D seismic data interpretation using RMS Amplitude and Envelope seismic attributes. The data used are secondary data from a reflection seismic survey processed at the Energy Study Centre. The interpretation stages include well-to-seismic tie, horizon picking, time structure mapping, and seismic attribute analysis. The interpretation results show that RMS Amplitude values in the Duri Formation range from 0.80 to 5.60, while in the Bekasap Formation, they range from 0.00 to 4.00. The Envelope attribute values in the Duri Formation range from 0.60 to 8.40, and from 0.50 to 6.00 in the Bekasap Formation. High attribute value zones are consistently detected around wells CAT_01, CAT_03, and northwest of CAT_02, corresponding to elevated topography based on the time structure map. These findings indicate potential hydrocarbon accumulation in the area, making it a prime target for field development and revitalisation. Seismic attribute interpretation offers an efficient exploration approach and supports future sustainable exploration efforts.

Keywords: reservoir characterisation, sandstone reservoir, seismic interpretation, well-to-seismic tie time structure map

INTRODUCTION

Over the past two decades, Indonesia has become a net oil importer due to continuously increasing domestic energy consumption, while national oil production has not shown significant growth. This imbalance has created an urgency to optimise the country's hydrocarbon resource potential by exploring and developing new oil and gas reserves. One of the regions with significant potential is the Central Sumatra Basin, which has historically been known as one of Indonesia's largest oil and gas producing areas.

The Central Sumatra Basin is a back-arc basin located in the central part of Sumatra Island. The Barisan Mountains bound it to the west and southwest, the Malaysian Peninsula to the east, the Asahan Arc to the north, the Tigapuluh Highlands to the southeast, and the Sunda Shelf to the northeast. In China, Southwestern Sichuan fold-thrust belt comprises an upper layer with NE–SW thrusts and a deeper basement-involved fold system with stronger deformation in the south, where structural styles vary regionally, and multiple favorable exploration targets exist in both layers, including anticlinal traps, rift-related structures, and paleo-uplifts. (Zhuxin et al., 2020). Therefore, the regional geological background—including structural framework, lithofacies distribution, and stratigraphic architecture—along with spatial variations in geothermal flow intensity, directly control the distribution pathways, migration dynamics, and accumulation zones of subsurface fluids (Wang et al., 2023) such as hydrocarbons or geothermal resources.

These geological and thermal controls are inherently linked to the basin's tectonic evolution, which governs both deformation styles and heat flow distribution. Tectonically, the basin was formed because of the subduction of the Indo-Australian Plate beneath the Eurasian Plate, which generated northwest–southeast trending anticlinal structures (Nainggolan et al., 2023). The basin's location is shown in Figure 1.

In this context, the urgency of this research lies in the need to enhance the effectiveness of oil and gas exploration, especially in fields that still hold untapped potential. One such area is the CAT Field, located within the Central Sumatra Basin, which has been identified as a region with remaining hydrocarbon prospects based on previous geological and geophysical studies (Klausen et al., 2022). Reservoir mapping and interpretation in this field are essential to support both technical and economic decisions for sustainable field development, particularly given the growing emphasis on maximizing recovery from mature or partially explored basins (Jia et al., 2023).

Seismic exploration activities are a primary tool for obtaining subsurface geological information, particularly in detecting the presence and distribution of hydrocarbon reservoirs. In this regard, seismic interpretation using attributes has produced sharper and more targeted results. Seismic attributes estimate reservoirs' physical and geometrical properties, visualise geological structures in greater detail, and evaluate hydrocarbon content potential (Emujakporue & Enyenihi, 2020). Time-based attributes provide structural information, while amplitude-based attributes offer insights into the stratigraphy and lithology of the reservoir, making them valuable tools in seismic interpretation workflows as **Seismic attribute** and petrophysics-assisted **interpretation** of the Nanushuk and Torok Formations on the North Slope, Alaska (Battacharya & Verma, 2020)

(*Author, Year*). The integration of these attributes has been widely applied to enhance

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reservoir characterization, especially in complex geological settings (Yang et al., 2021). Building upon this foundation, this study explores the application of both supervised and unsupervised machine learning approaches to forecast key petrophysical properties that are critical for evaluating reservoir quality. (Al-Fikih et al., 2023).

This study applies two amplitude-based attributes—RMS Amplitude and Envelope—to map prospective hydrocarbon reservoir zones in the CAT Field. The RMS Amplitude attribute reflects the average energy strength of the seismic signal within a given time interval. In contrast, the envelope attribute highlights the maximum amplitude variation, which helps delineate lithological boundaries and identify hydrocarbon accumulation zones.

Mapping these two attributes is then overlaid onto the time structure maps of the target formations—namely, the Duri and Bekasap Formations—to improve prediction accuracy and confirm prospective zones. This integrated interpretation approach enhances the technical effectiveness of oil and gas exploration activities and promotes more selective and efficient exploration, thereby reducing the environmental impact of misguided drilling activities.

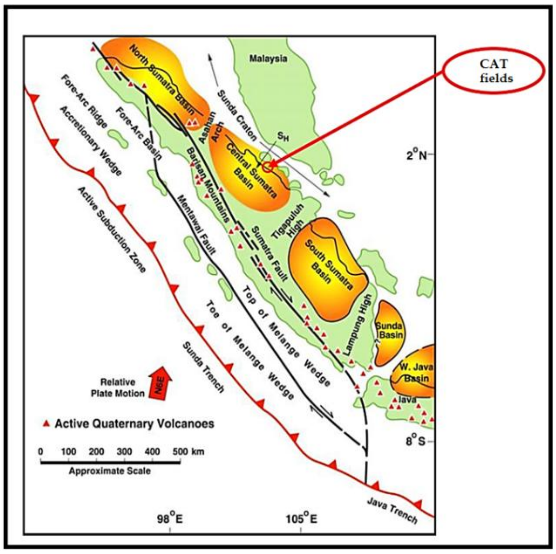


Figure 1. Location of the Central Sumatra Basin

By supporting national energy security by identifying potentially productive domestic reserves and encouraging the use of precise and responsible exploration technologies, this research aligns with the principles of sustainable development. These include expanding access to reliable energy, fostering innovation in industry, and managing natural resources wisely for the benefit of future generations.

METHODS

The study was conducted in the CAT Field, located within the Central Sumatra Basin—one of Indonesia's most productive hydrocarbon basins. This location includes four exploration wells that serve as reference points for interpretation: CAT_01, CAT_02, CAT_03, and CAT_04, as shown in Figure 2. The base map illustrates the spatial distribution of the wells and the boundary of the exploration working area, which forms the primary scope of this study.

This research adopts a 3D seismic interpretation approach based on the Post Stack Time Migration (PSTM) method, supported by supplementary data such as well data (logs, checkshots, and stratigraphic markers), regional geological data, and the local petroleum system. The seismic dataset consists of 475 inlines and 420 crosslines, with a grid spacing of 20 meters, enabling sufficient spatial resolution for structural and stratigraphic analysis. The interpretation process used CGG Hampson Russell Suite 10.3.2 and Schlumberger Petrel E&P Platform 2018, offering strong seismic data processing, visualisation, and advanced seismic attribute application capabilities. Data processing and analysis workflow:

Preliminary Analysis and Data Integration: Seismic and well data were analysed to understand the initial subsurface conditions. Reflection coefficients were calculated using density and sonic logs to generate synthetic seismograms.

Well-to-Seismic Tie: Using checkshot data and synthetic seismograms, a correlation was made between log data (in depth) and seismic data (in time). The correlation is considered valid when the correlation coefficient exceeds 0.5. This process is essential to link stratigraphic markers (such as Top Duri and Top Bekasap) with the actual seismic reflection responses.

Reservoir Geometry Interpretation: Once the well tie was completed, horizon picking and fault picking were conducted to identify major reflector boundaries and faults affecting reservoir continuity. The picking results were used to generate time structure maps for the two target formations: the Duri Formation and the Bekasap Formation.

Seismic Attribute Application: Amplitude attributes such as RMS Amplitude and Envelope were applied to the interpreted intervals based on horizon picking. The RMS attribute detected amplitude anomalies representing high-porosity zones or fluid accumulations. The Envelope attribute highlighted stratigraphic boundaries and lithological contrasts based on maximum amplitude variations.

Attribute Mapping and Overlay: RMS and Envelope attribute results were displayed as attribute slice maps at specific time intervals and overlaid to strengthen the identification of prospective zones. Final interpretation was performed by integrating attribute datasets and spatial validation with well positions.

Prospect Zone Analysis: Zones with high RMS and Envelope values associated with time structure highs were considered areas with the highest potential for hydrocarbon accumulation. Validation was performed using stratigraphic markers and hydrocarbon log data from existing wells.

All stages are summarised in the flowchart shown in Figure 3, which illustrates the workflow from data acquisition and correlation processes to horizon and fault interpretation, seismic attribute analysis, and spatial visualisation of hydrocarbon prospect zones.

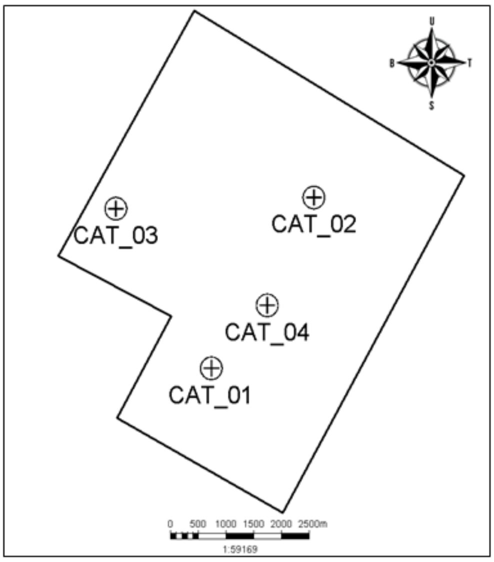


Figure 2. Base Map of the CAT Field

RESULTS AND DISCUSSION

Identification of Hydrocarbon Reservoir Distribution Potential in the CAT Field, Central Sumatra Basin

Based on the available dataset, one of the initial analyses conducted was the correlation of well data within the study area. This well-log correlation aimed to identify the lateral continuity of geological horizons across the four wells by matching formation markers and to delineate potential hydrocarbon-bearing zones. As illustrated in Figure 4, the correlation results show consistent marker alignments for the Telisa (T_TE), Duri (T_D), and Bekasap (T_BK) formations across wells CAT_01 through CAT_04.

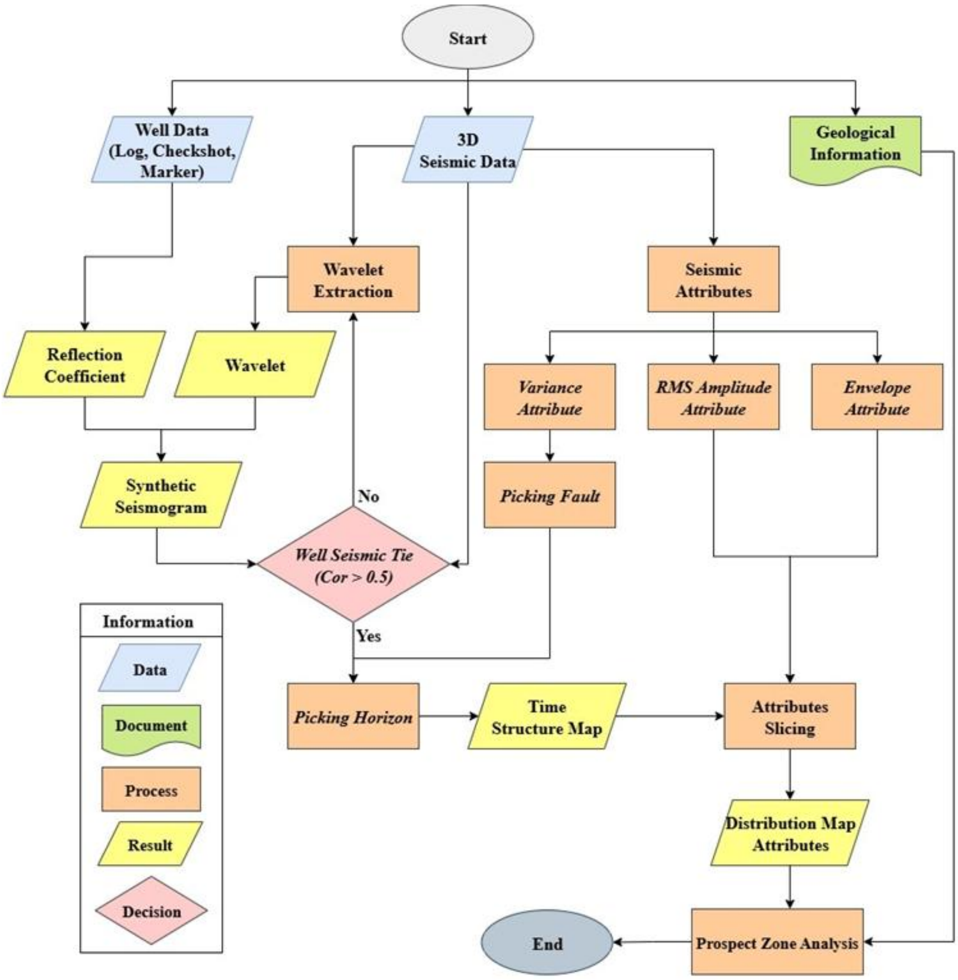


Figure 3. Research Workflow Diagram

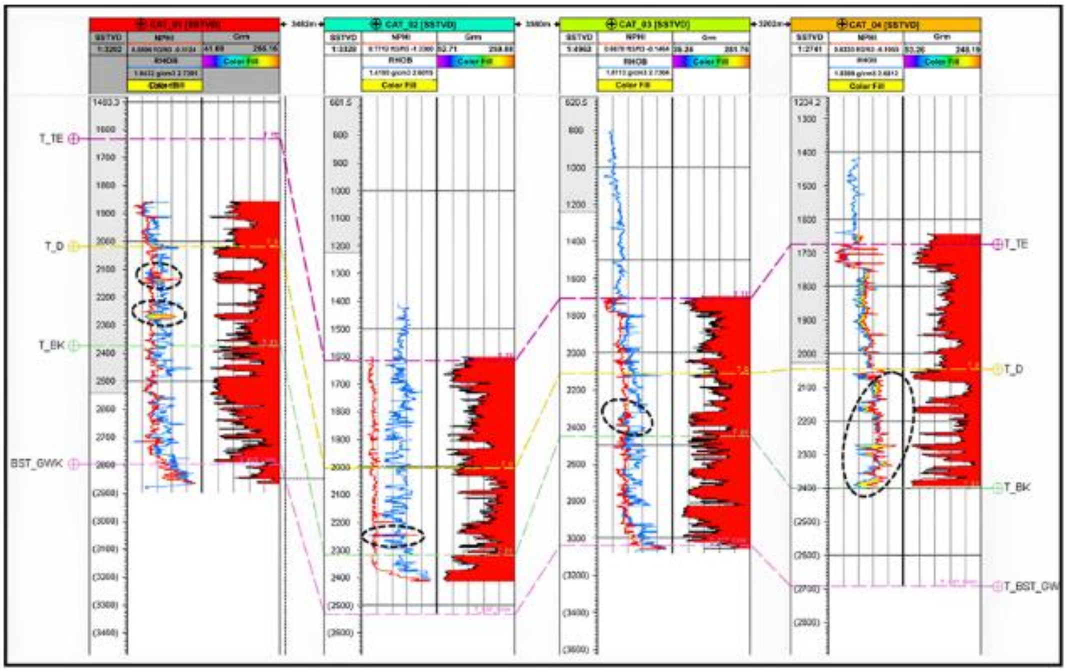


Figure 4. Correlation of the Four Wells in the CAT Field

Anomalies in the log responses—particularly low gamma ray values, crossover effects between density and neutron porosity (NPHI) curves, and sudden drops in bulk density (RHOB)- suggest potential reservoir zones. These responses are especially notable in the interval between the Duri and Bekasap formations (T_D to T_BK), indicating permeable sandstone layers likely to serve as hydrocarbon reservoirs. This interpretation is consistent with previous research (Andriyani et al., 2023), which showed that similar log characteristics are associated with oil- and gas-bearing formations, notably where RHOB decreases sharply and stabilises, gamma ray readings are low, and NPHI values are also reduced. The consistent alignment of markers and indicative log responses across all four wells further supports the identification of a prospective hydrocarbon zone, making this interval a focus for subsequent seismic interpretation and attribute analysis.

Well-to-Seismic Tie and Structural Mapping

Before generating the time structure map, the formation markers from the well data must be correlated with the seismic data through a well-to-seismic tie process. This process aims to link seismic reflections to their true subsurface depths using well log data. The correlation is focused on the target interval or formation of interest, using a synthetic seismogram as the primary correlation tool (Sukmono & Ambasari, 2019) to ensure alignment between geological information from the well logs and seismic responses. Once the correlation is established, the final Vs and Vp cube models are generated using well logs, DSI data, and geostatistical methods, showing strong correlation with acoustic impedance and formation properties. These models enable reliable fracture pressure estimation and lithology characterization—with a Vs correlation of 0.95, AI values of 8000–15000 [(m/s)(g/cm³)] linked to calcareous units, and a maximum classification accuracy of 0.74 in dominant limestone intervals ((Kianoush et al., 2022).

Achieving a perfect correlation is often challenging due to differences in frequency content between well log data and seismic data. In addition, subsurface layers can act as filters during wave propagation, further complicating the correlation process (Sidiq et al., 2019). This study conducted the well-to-seismic tie for four wells—CAT_01, CAT_02, CAT_03, and CAT_04—with correlation coefficients above 0.5. The results showed consistent peak alignment across all wells, as summarised in Table 1.

Table 1. Formation well to seismic tie at four wells

Well	Formation				Corr
	Telisa	Duri	Bekasap	Basement	
CAT_01	Peak	Peak	Peak	Peak	0,614
CAT_02	Peak	Peak	Peak	Peak	0,616
CAT_03	Peak	Peak	Peak	Peak	0,586
CAT_04	Peak	Peak	Peak	Peak	0,551

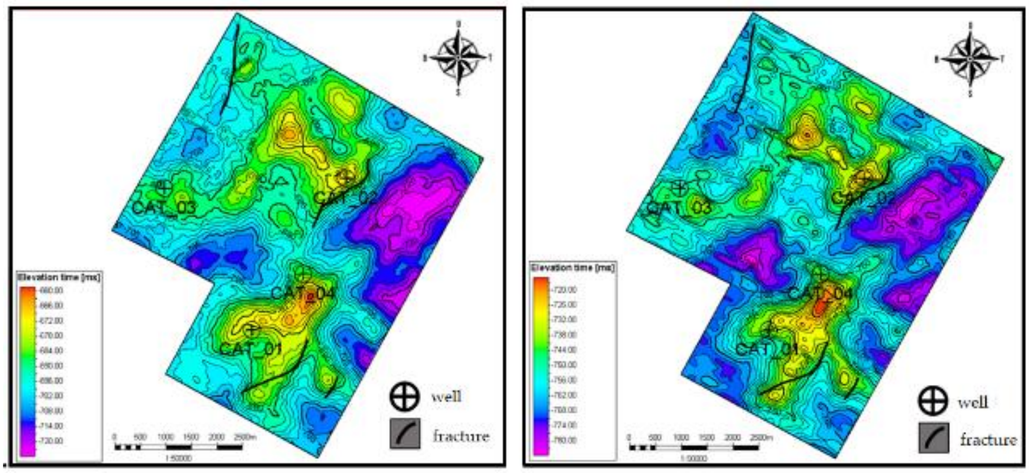
Time Structure Mapping of the Duri and Bekasap Formations

This process results in a correlation between the synthetic seismogram and well log data in the form of a depth–time relationship. Moreover, all four wells exhibit consistent marker placements for each formation, with horizons aligned with seismic peaks. This consistency confirms the reliability of the correlation and allows the interpretation to proceed to the fault and horizon picking stages. The interpreted horizons are then used to construct time structure maps for the target formations, namely the Duri and Bekasap formations. The time structure map shown in Figure 5a provides valuable insights into the subsurface geology of the Duri Formation. Interpreted from 3D seismic data, this figure illustrates elevation time in milliseconds (ms), with colour gradients representing depth variations—shallower structures are indicated by red to yellow tones. At the same time, deeper zones appear from green to purple. Several structural highs are observed near wells CAT_01, CAT_02, CAT_03, and CAT_04, suggesting favourable conditions for hydrocarbon accumulation. The presence of faults further highlights structural complexities that may influence reservoir distribution, fluid migration, and trap formation. As part of the seismic interpretation workflow, this figure is crucial in delineating potential reservoir zones within the Duri Formation.

The time structure map of the Bekasap Formation, as illustrated in Figure 5b, reveals the subsurface geometry based on elevation time (in milliseconds). Shallow zones are represented by warm colours (yellow to red), while deeper areas are depicted with cooler tones (green to purple). Several structural highs around wells CAT_01 to CAT_04 can be observed, indicating zones with potential hydrocarbon accumulations. The map also highlights fault lines that intersect the formation, which may function as migration pathways or trapping mechanisms for hydrocarbons. Through this visualisation, the spatial relationship between the structural highs, fault systems, and well locations become evident, aiding in identifying prospective reservoir zones within the Bekasap Formation.

The colour gradients on the surface maps represent variations in structural elevation, where warmer colours (e.g., red and yellow) indicate relatively shallower areas, and cooler colours (e.g., blue to purple) correspond to deeper regions. The time structure map of the Duri Formation, as shown in Figure 5a, displays elevation times ranging from 660 ms to 720 ms, while the Bekasap Formation, depicted in Figure 5b, has elevation times between 720 ms and 780 ms.

Both maps show that all four wells (CAT_01 to CAT_04) are located within structural highs, commonly favourable zones for hydrocarbon accumulation. Additionally, several fault structures are visible across both formations. These faults may serve as migration pathways, facilitating the movement of hydrocarbons from the source rock to the reservoir zones (Ordas et al., 2023). Integrating elevation and fault data in these structural maps is vital in assessing subsurface prospectivity and determining hydrocarbon-bearing zones within the study area.



(a) (b)

Figure 5. Time Structure Map (a) the Duri Formation, (b) the Bekasap Formation

RMS Amplitude Attribute Analysis

Applying the RMS Amplitude attribute aims to analyse reservoir distribution based on amplitude parameters in the time domain of seismic sections. This attribute is sensitive to extreme amplitude values, which facilitates the identification of significant lithological changes such as sandstone, gas, and deltaic channels (Aviani et al., 2022).

The RMS Amplitude values in the Duri Formation range from 0.80 to 5.60, while in the Bekasap Formation, they range from 0.00 to 4.00. Seismic responses from sandstone reservoirs typically produce high amplitude values. Reservoirs with sandstone lithology tend to have lower density and higher porosity, which can be filled with water, oil, or gas. These properties result in different acoustic impedance responses between the reservoir rocks and the surrounding formations. Wave velocity also influences acoustic impedance, which affects reflection coefficient changes. The reflection coefficient represents the contrast between two media with differing acoustic impedances (Onajite, 2014). Changes in reflection coefficients, observed as increased amplitude on seismic data, typically indicate sandstone reservoirs.

The RMS Amplitude attribute slice map of the Bekasap Formation is shown in Figure 6b. This map results from seismic attribute interpretation aimed at identifying zones with high amplitude anomalies often associated with hydrocarbon accumulations.

In this figure, the colour spectrum represents surface attribute values, where red to yellow colours indicate high RMS Amplitude values (≥ 3.00), potentially highlighting the presence of hydrocarbon reservoir zones, mainly if the area is located on a structural high. Blue to purple reflect lower amplitude values (< 1.80), generally indicating non-productive layers or cap rocks.

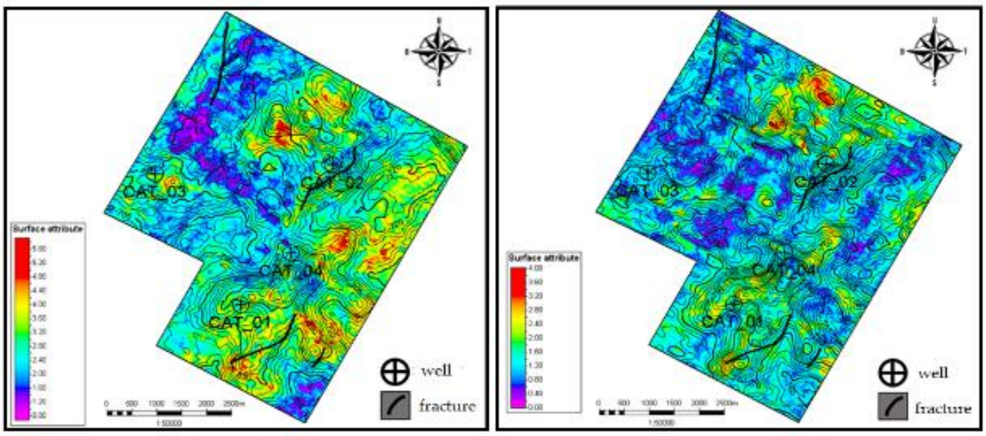
The four wells (CAT_01, CAT_02, CAT_03, and CAT_04) are located in areas with varying RMS Amplitude values, with some near high anomalies. The faults on the map also play an important role as hydrocarbon migration pathways from the source rock to the reservoir.

Thus, identifying prospective zones is supported by integrating structural information (faults and well locations) and seismic information (amplitude anomalies), which is the basis for determining further exploration targets within the Bekasap Formation, as shown in Figure 6.

The RMS Amplitude attribute slice maps of the Duri and Bekasap Formations are shown in Figures 6a and 6b. Sandstone reservoirs generally exhibit seismic responses in high amplitude values, which can be identified through this attribute. Areas shown in shades approaching red represent high RMS Amplitude values, which geologically can be interpreted as zones of sandstone reservoir distribution. Conversely, lower amplitude values are represented by colours approaching purple, typically indicating non-reservoir layers or zones that are not significant in hydrocarbon potential. The interpretation of this attribute is essential for estimating the lateral distribution of the reservoir and supports decision-making in determining future drilling locations.

Identification of gas zones and chimneys using seismic attributes analysis at the Scarab Field, offshore, Nile Delta Egypt, stated that seismic attributes supported by well log data are an effective means of interpreting and understanding seismic data, offering new insights into the output results (Ismail et al., 2020). The Envelope attribute, or reflection strength attribute, is applied to determine reflection strength values, which can be used to identify acoustic impedance contrasts interpreted as gas channels and bright spots (Kadkhodaie & Kadkhodaie, 2022).

The Envelope attribute values in the Duri Formation range from 0.60 to 8.40, while in the Bekasap Formation, they range from 0.50 to 6.00. As the name suggests, this attribute characterises the strength of reflection zones based on their seismic amplitudes. Higher values are represented by shades closer to red, whereas lower values approach purple tones.



(a) (b)

Figure 6. RMS Amplitude Attribute Slice Map (a) the Duri Formation, (b) the Bekasap Formation

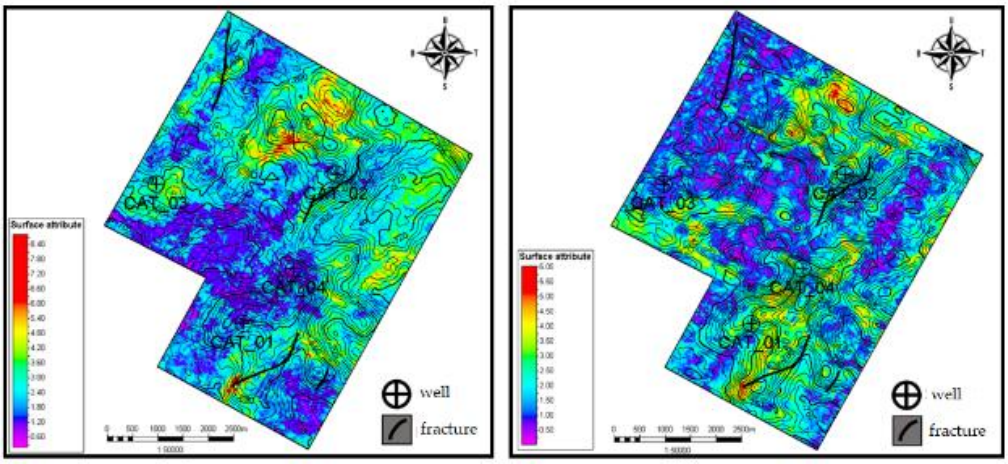
Slice maps are necessary to assist in interpreting potential hydrocarbon reservoir areas, such as sandstone. High Envelope attribute values are associated with potential zones, indicated by yellow to red colour gradients. The distribution of these values can be observed in the attribute slice maps of the Duri and Bekasap Formations shown in Figures 7a and 7b. Displays the Envelope attribute slice map for the Duri Formation (left) and the Bekasap Formation (right) shown in Figure 7a. The Envelope attribute reflects the strength or total energy of the seismic amplitude signal and is commonly used to identify high-amplitude zones that may correspond to hydrocarbon accumulations.

Red to yellow indicates high Envelope values, suggesting strong reflections typically correlated with porous and permeable zones, such as hydrocarbon-saturated sandstone reservoirs. Conversely, blue to purple colours reflect lower Envelope values, likely representing non-reservoir zones or rocks with insignificant reflection energy.

Both maps show different spatial distributions of reflection energy across the formations. However, the consistent red zones around wells CAT_02 and CAT_04 strengthen the indication of potential hydrocarbon prospect zones in those areas. The combined attribute analysis is crucial for lateral reservoir validation and enhances the reliability of productive zone interpretation.

Similar results observed at Well SWAN-14, situated in a low-reflection zone with low Envelope values, suggest lower productivity potential than wells SWAN-01, SWAN-07, and SWAN-08, which lie in high-reflection areas. These high Envelope values suggest the presence of thick sand layers functioning as reservoirs (Ashraf et al., 2019). A similar observation was made in the Foz do Amazonas

Basin, Northern Brazil, where the use of the Envelope attribute significantly enhanced the visualization and Identification of the Bottom Simulating Reflector (BSR), as this attribute effectively distinguishes lithology and stratigraphic variations within reservoir zones and detects gas and fluid accumulations (Aguiar et al., 2019). Seismic reflection analysis enables the identification of trapped gas beneath the BSR.



(a) (b)

Figure 7. Envelope Attribute Slice Map (a) the Duri Formations, (b) the Bekasap Formation

In addition, Envelope attribute slicing in other studies has demonstrated success in mapping carbonate reservoir distribution, indicated by high Envelope values ranging from 30 to 40, with colour gradients from yellow to red (Yuniarto, 2021). Based on these findings, the zones with high Envelope values in this study's Duri and Bekasap Formations are prospective areas potentially containing hydrocarbon reservoirs.

Overlay Map on Formation Location

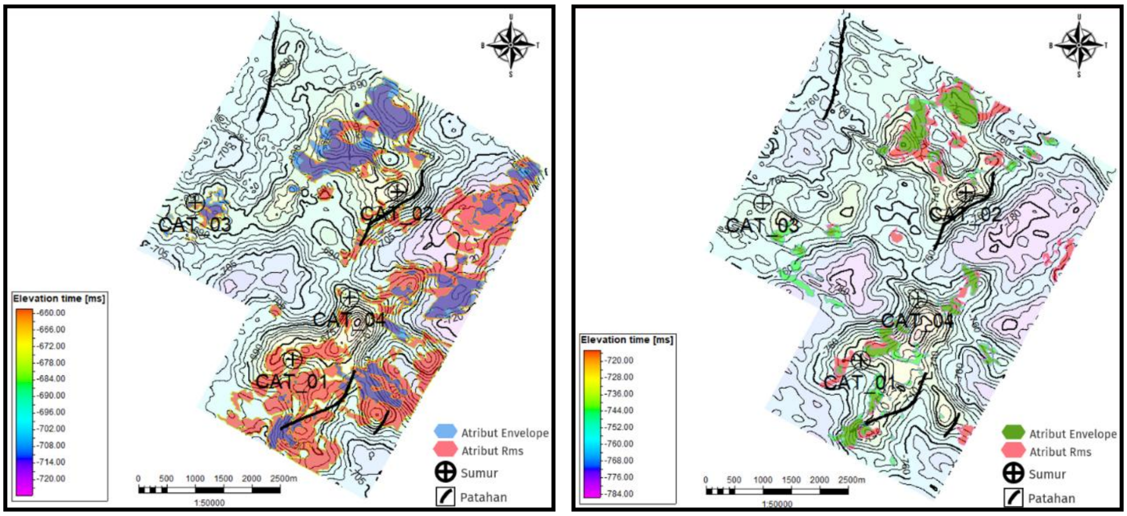
To strengthen the assumption regarding sandstone reservoirs in the Duri and Bekasap Formations, both attributes were overlaid to confirm whether the areas in question represent potential zones. The overlay map of Envelope and RMS Amplitude attributes for the Duri Formation is shown in Figure 8a. The map reveals areas where the two attributes overlap, indicating potential reservoir zones, although there are also zones without intersection. For instance, at wells CAT_04 and CAT_02, the map shows low amplitude values and location within low-reflection zones, suggesting relatively low hydrocarbon productivity. Meanwhile, the distribution of sandstone reservoir zones tends to be located in structurally higher areas, indicating the role of these zones as hydrocarbon accumulation sites due to fluid migration from source rocks.

Though limited in extent, the presence of high RMS Amplitude and relatively high Envelope values at wells CAT_01 and CAT_03 indicates that these wells are located in more prospective zones with potentially better productivity potential.

Additionally, there is a zone with strong responses from both attributes located to the northwest of well CAT_02, situated on structurally higher ground compared to the southeastern area of the well. Hydrocarbons tend to migrate toward structural highs, so this zone holds potential as a promising hydrocarbon prospect, as supported by previous studies indicating that structural highs often serve as effective hydrocarbon traps in similar geological settings (Fangzheng, et al., 2020).

The overlay map of Envelope and RMS Amplitude attributes for the Bekasap Formation is shown in Figure 8b. Compared to the Duri Formation, fewer prospective zones are detected in this formation. However, the attribute response pattern shows a similar trend. Wells CAT_02 and CAT_04 again lie within areas of low attribute response, while CAT_01 and CAT_03 display higher RMS and Envelope responses, indicating greater hydrocarbon productivity potential.

Consistent with previous observations, the area northwest of well CAT_02 exhibits high attribute responses, and due to its position on a structural high, this zone is also considered a viable hydrocarbon prospect within the Bekasap Formation, indicating favorable reservoir conditions and hydrocarbon accumulation.



(a) (b)

Figure 8. Overlay Map (a) the Duri Formation, (b) the Bekasap Formation

CONCLUSION

Based on the results of this study, it can be concluded that the interpretation of RMS Amplitude and Envelope seismic attributes in the CAT Field, Central Sumatra Basin, effectively delineates the distribution of prospective reservoir zones within the Duri and Bekasap Formations. These zones are characterized by consistently high RMS and Envelope values, which reinforce each other both spatially and in intensity. Attribute overlays (Figures 8a and 8b) highlight areas of convergence—particularly around wells CAT_01, CAT_03, and northwest of CAT_02—that correspond to sandstone reservoir indicators situated on structurally higher features. These structural highs are favorable for hydrocarbon accumulation, serving as migration endpoints from source rocks into traps. Conversely, wells CAT_02 and CAT_04 lie in areas with lower attribute responses and subdued structural settings, suggesting limited reservoir potential. Overall, the integration of attribute and structural mapping proves effective in identifying key hydrocarbon prospects in the CAT Field, providing a robust basis for more focused, efficient exploration while reducing the risk of unproductive drilling.

REFERENCES

Aguiar, L., Freire, A., Santos, L. A., Dominguez, A. C., Neves, E., Silva, C., & Santos, M. A. (2019). *Analysis of Seismic Attributes To Recognise Bottom Simulating Reflectors In The Foz Do Amazonas Basin, Northern Brazil*. *August* 1–5.

Al-Fakih, A., Kaka, S. I., & Koeshidayatullah, A. I. (2023). Reservoir property prediction in the North Sea using machine learning. *IEEE Access*, *11*, 140148-140160.

Andriyani, D. C., Winardi, S., & Surjono, S. S. (2023). Petrophysical Study and Rock Type Determination of Siliciclastic Reservoir: Case Study Sand of Bekasap Formation, AF Field, Central Sumatra Basin, Indonesia. *Journal of Applied Geology*, *7*(2), 122-138.

Aviani, N., Warnana, D. D., Komara, E., & Afdhal, R. F. (2022). Analisis Seismik Atribut Untuk Identifikasi Persebaran Reservoir Batupasir Pada Formasi Balikpapan, Lapangan V. *Jurnal Geosaintek*, *8*(2), 200–205.

Bhattacharya, S., & Verma, S. (2020). Seismic attribute and petrophysics-assisted interpretation of the Nanushuk and Torok Formations on the North Slope, Alaska. *Interpretation*, *8*(2), SJ17-SJ34.

Emujakporue, G. O., & Enyenihi, E. E. (2020). Identification Of Seismic Attributes For Hydrocarbon Prospecting Of Akos Field, Niger Delta, Nigeria. *SN Applied Sciences*, *2*(5), 1–11.

Fangzheng, J. I. A. O., Caineng, Z. O. U., & Zhi, Y. A. N. G. (2020). Geological theory and exploration & development practice of hydrocarbon accumulation inside continental source kitchens. *Petroleum Exploration and Development*, *47*(6), 1147-1159.

Farfour, M., & Foster, D. (2022). Detection of hydrocarbon-saturated reservoirs in a challenging geological setting using AVO attributes: A case study from Poseidon field, Offshore Northwest region of Australia. *Journal of Applied Geophysics*, *203*, 104687.

Ismail, A., Ewida, H. F., Al-Ibiary, M. G., Gammaldi, S., & Zollo, A. (2020). Identification Of Gas Zones And Chimneys Using Seismic Attributes Analysis At The Scarab Field, Offshore, Nile Delta, Egypt. *Petroleum Research*, *5*(1), 59–69.

Jia, D., Zhang, J., Li, Y., Wu, L., & Qiao, M. (2023). Recent development of smart field deployment for mature waterflood reservoirs. *Sustainability*, *15*(1), 784.

Kadkhodaie, A., & Kadkhodaie, R. (2022). Acoustic, density, and seismic attribute analysis to aid gas detection and delineation of reservoir properties. *Sustainable Geoscience for Natural Gas Subsurface Systems*, 51-92.

Kianoush, P., Mohammadi, G., Hosseini, S. A., Keshavazr Faraj Khah, N., & Afzal, P. (2022). Compressional and shear interval velocity modeling to determine formation pressures in an oilfield of SW Iran. *Journal of Mining and Environment*, *13*(3), 851-873.

Klausen, T. G., Alaei, B., & Patel, D. (2022). Overview of Seismic Attributes and Seismic Object Extraction. In *Interactive Data Processing and 3D Visualization of the Solid Earth* (pp. 79-114). Cham: Springer International Publishing.

Nainggolan, T. B., Kusnida, D., Mimanda, E., Setiadi, I., Nugroho, E. H., & Subagio, S. (2023). Delineating Sub-Basins of Sedimentary Rock Structure Beneath Eastern Central Sumatra Basin Using Integrated Gravity , *Seismic and Well Data Analysis*. 1–22.

Ordas, P. R., Andurrokhim, Sendjaja, Y. A., &

Nainggolan, T. B. (2023). Analisis Lingkungan Pengendapan Dan Sistem Petroleum Berdasarkan Integasi Data Seismik Dan Sumur Di Pesisir Cekungan Sumatra Tengah. *Jurnal Ilmu Dan Teknologi Kelautan Tropis*, *15*(2), 149–165.

Sidiq, A. P., Manik, H. M., & Nianggolan, T. B. (2019). Studi Komparasi Metode Migrasi Seismik Dalam Mengkarakterisasi Reservoir Migas Di Blok Kangean, Laut Bali Menggunakan Inversi Impedansi Akustik Berbasis Model. *Jurnal Ilmu Dan Teknologi Kelautan Tropis*, *11*(1), 205–219.

Sukmono, S., & Ambasari, D. S. (2019). Practical Interpretation For Petroleum Exploration. In *Экономика Региона*. ITB Press.

Wang, J. Q., Liang, J., Chen, J. W., Zhao, Q. F., Zhang, Y. G., Zhang, J. W. & Jiang, L. J. (2023). The accumulation characteristics and exploration potential of oil and gas in the back-arc basin of Japan under the background of high heat flow. *China Geology*, *6*(4), 660-675.

Yang, J., Qi, N., Lu, S., Wang, M., Lu, M., & Xia, Y. (2021). Reservoir characterization and geological controls of the Lower Cretaceous sandstones in the northern Wuerxun Sag, Hailar Basin, China. *Journal of Petroleum Science and Engineering*, *205*, 108771.

Yuniarto, A. H. P. (2021). Karakterisasi Reservoir Karbonat Akustik Dan Atribut Seismik Di Lapangan " Clm " Cekungan Jawa Barat Utara. *Jurnal Ilmu Dan Inovasi Fisika*, *05*(02), 95–104.

Zhuxin, C. H. E. N., Lining, W. A. N. G., Guang, Y. A. N. G., Danlin, Y. I. N. G., Baoguo, Y. U. A. N., Senqi, P. E. I., & Wei, L. I. (2020). Geological structures and potential petroleum exploration areas in the southwestern Sichuan fold-thrust belt, SW China. *Petroleum Exploration and Development*, *47*(4), 699-713