Unveiling the Talang Akar GRM Sedimentary Facies to Define Reservoir Distribution in North Musi, South Sumatra Basin

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***Abstract*—Oil and Gas Exploration activities in North Musi Cluster, South Sumatra Basin at PERTAMINA EP Block had been inactive since Mambang Field stopped producing in 2005. However, in 2024, a recent hydrocarbon discovery was made in the area from the DPT wildcat exploration well, which flowed & tested rate of 200 BOPD and 0.6 MMSCFD from drill stem test at Grid Sand Member (GRM) Talang Akar Formation. This recent discovery has opened new opportunities for exploitation and exploration activity. This well is a stratigraphic play opener in the area, shown through the Talang Akar Formation (TAF GRM) geological model, built from well data and 3D seismic data. A robust depositional model of TAF GRM is created through integration of well data, such as Gamma Ray log Correlation, Borehole Image Interpretation, Biostratigraphy Analysis and seismic data such as Sweetness seismic attribute which in turn unveil the full stratigraphic play potential within the North Musi Cluster.**

***Keywords*—Talang Akar formation, stratigraphic play, borehole image, sweetness attribute**

I. Introduction

Lower Talang Akar Formation or also well known as Grid Sand Member (GRM) is a productive reservoir within the South Sumatra Basin. Talang Akar GRM was deposited as prograding and transgressive phase, in which through sequence stratigraphy is divided into low stand system tract and transgressive system tract.

Talang Akar formation in North Musi area (PERTAMINA EP Block), has historically served as a productive reservoir, notably through the Mambang field since 1915, primarily as a structural trapping play until production ceased in 2005. In 2010, the GNY exploration well was drilled and flowed <1 MMSCFD and 43 BCPD at GRM TAF (Talang Akar Formation) level categorizing it as an uneconomic discovery. GNY is known as a four-way dip closure or structural trap. Recently, in 2024 the Direct Push Technology (DPT) Exploration well was drilled and discovered hydrocarbon from within the TAF GRM as confirmed through the drill stem test which yielded approximately 200 BOPD. This discovery opened the possibility of stratigraphic play within the area, supported by the TAF GRM geological model, built from well data and 3D seismic data.

This study reveals the stratigraphic play opportunities of the TAF GRM through an integrated analysis of borehole imaging data from the DPT well exploration drilled and discovered in 2024, along with 3D seismic data acquired in 2013. Based on facies association, the deposition environment is interpreted as a prograding-transgressive delta. The objective of this study is to map out the distribution of TAF GRM facies by creating a deposition model, thereby unveiling future exploration and exploitation potential within the North Musi area of the South Sumatra Basin, particularly focusing on Talang Akar GRM.

A. Regional Geology

North Musi area is located within the Musi Rawas Regency, South Sumatra Province Fig. 1. Both geologically and geographically, the North Musi area is bounded by Klingi or Pigi Deep in the southwest part, Central Palembang Basin in the southeast Musi Platform in the northeast part [1]. The North Musi area is part of Sebakul uplift and lineament with Lematang fault trend as a part of strike slip system product [2]. This local uplift is developed as a transgressional event at Pliocene age (northwest-southeast oriented).

North Musi Cluster is highly potential for hydrocarbon exploration and production due to its strategic location between two source rock kitchens, the Pigi Deep in the southwest and the Central Palembang sub-Basin in the northwest along with two local provenance sources, the Sebakul High and Musi High. The TAF GRM is also particularly promising as it is deposited in a Deltaic System. These distinctive geological features indicate that during the Pliocene epoch, which also coincides with peak migration, the North Musi Cluster became a

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favorable area for hydrocarbon accumulation, serving as initial trap.

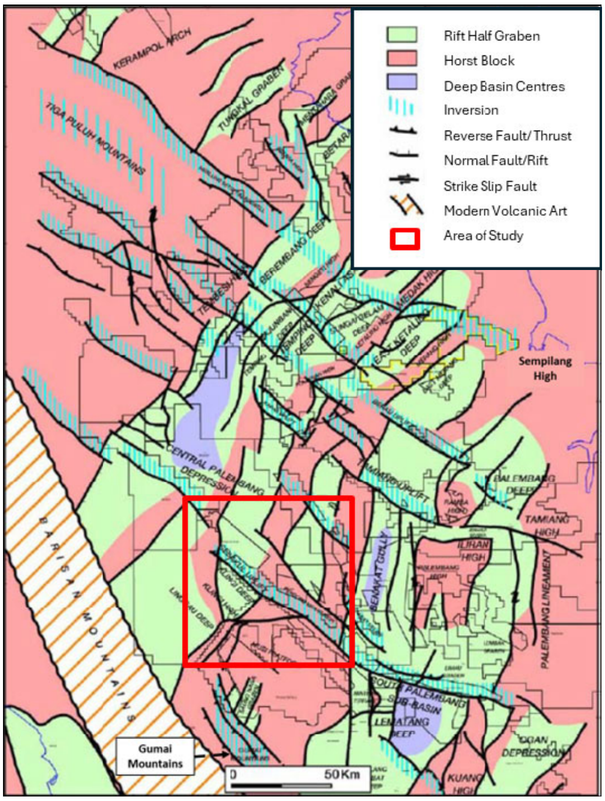


Fig. 1. Area of Study located in Musi Rawas Regency, South Sumatra Province.

B. Tectonic Setting and Stratigraphy

The tectonic history and stratigraphic record of the South Sumatra Basin can be tectonostratigraphically divided into at least five phases Fig. 2:

1. Basement configuration of South Sumatra Basin [3] associated with pre-Tertiary convergent tectonics. The basement rocks are interpreted as part of the Woyla continental crust, Malacca Microplate and Mergui Microplate.
2. Sedimentary rock deposition started during the extensional phase at the Paleogene, due to a rift basin formation. This extension produces a sequence of north-south trending horst graben, in which during the Miocene, it further evolved to create the present-day trend of North-Northeast–South-Southwest [4]. It was also during the late Paleogene that the Lemat or Lahat formation was deposited in a lacustrine and marginal lacustrine environment which has source rock potential in this basin.
3. During the Late Oligocene to Early Miocene, early post-rift period characterized through transgressive stratigraphic sedimentation of Talang Akar Formation sandstone [5] and the deposition of Baturaja limestone on paleo highs, in which both has reservoir potential. The Lower Talang Akar Formation or Grid Sand Member (GRM) was deposited in a channel-fill, crevasse play, point bar sandstones of fluvio-deltaic, delta plain channel delta-front, river mouth-bar and marine barrier-bar environments. During Early to Middle Miocene, marine transgression of Gumai shale dominated the whole basin which generally creates a regional seal within the South Sumatra basin.
4. During the Middle to Late Miocene, as low sagging phase occurred. This late post-rift phase is marked through a regressive stratigraphic sedimentation of the Air Benakat Formation, belonging to the Lower Palembang Group. The formation is characterized by shallow marine-transitional facies with a dominant lithology of sandstone and conglomerate with interbedded mudstone, and an increasing abundance of volcanic content towards the western edge of the basin.
5. Lastly, during the Pliocene to Recent time, the region undergoes Tectonic inversion phase. This phase reactivated Paleogene-aged normal fault structures, forming anticlinal and synclinal hydrocarbon traps.

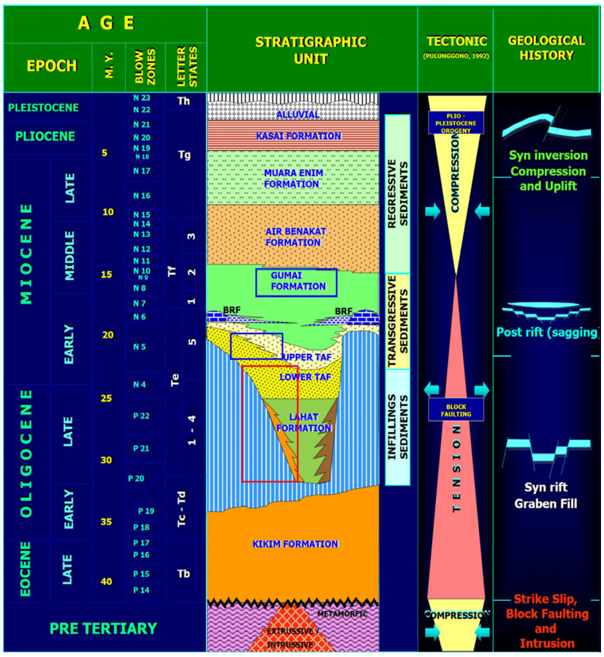


Fig. 2. Tectonostratigraphy of study area [6].

II. Data and Method

A. Data

The area of interest of this study is in the North Musi Cluster, within the South Sumatra Basin using 4000 sqm of 3D post-stack seismic data, Mambang and GNY wells data and borehole image log from DPT well data, as shown Table I.

3D Seismic Data is land acquisition in 2011, with standard processing sequenced, generated post stack data seismic with quality fair to good.

TABLE I. DATA AVAILABILITY

No	Data
1	3D Seismic Post Stack Data
2	Log GR Mambang, GNY, DPT Well Data
3	Borehole Image DPT Well Data

B. Method

The primary objective of this study is to define and map out the distribution of Talang Akar GRM facies through robust analysis utilizing seismic attributes, well correlation, paleocurrent analysis from borehole image data, and biostratigraphy analysis.

Sweetness attribute is used to map out areas that contain higher amplitude and lower frequencies which correlate with sandy interval [7].

The gamma ray log pattern and borehole image log are used to identify sedimentary facies and sequence stratigraphic of Talang Akar GRM.

There is a depositional related spatial relationship between rifting time and distance from sediment source. Proximal sedimentation has blocky to coarsening up gamma ray log pattern, meanwhile distal sedimentation has serrated pattern. This gamma ray log patterns have different depositional environments. Blocky log pattern can deposit as fluvial channel, prograding delta, while coarsening upward can deposit as crevasse splay, mouth bar, delta front-pro delta, and serrated pattern can deposit as fluvial flood plain Fig. 3 [8].

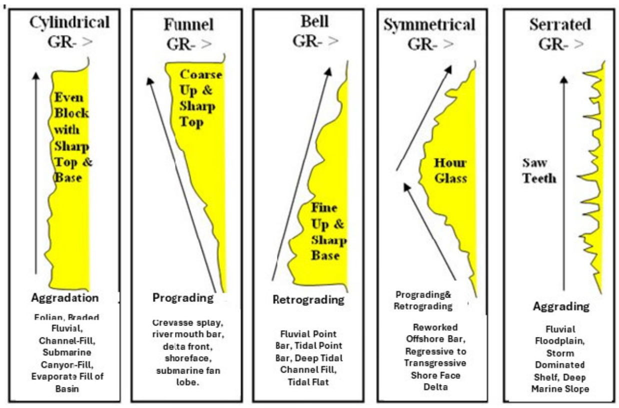


Fig. 3. Correlation between Log shape and deposition environment [8].

Biostratigraphy analysis correlates ages of rock strata using fossil. The faunal and plant fossil can help identify relative sea level changes, which is reflection of the paleoenvironment.

Borehole image log data act as a guide in interpreting formation facies, formation dip and advance geological analysis such as structural, sedimentological and sequence stratigraphy. Borehole image interpretation helps to accurately determine structural dips.

Furthermore, structural dip analysis is used to reconstruct the paleocurrent from cross bedding dips. In principle the method works by rotating back the tilted structural strata into the original flat condition (mostly low energy sedimentary rock such as shale dip). In this study, all dips picked in the sand lithology were initially classified as sand dips. After the structural dips had been removed, the sand dips were reclassified. Those who have dip magnitude less than 10 degree remained as sand dips, whereas those who have dip magnitude more than 10 degree were reclassified into cross bedding dips [9].

Facies description is a combination of lithology, texture, and structures. In this study, lithology was derived from mud logs and conventional logs. Whereas texture and structures were interpreted based on borehole image log appearance from DPT well.

III. RESULTS AND DISCUSSION

Gamma Ray logs correlation at Talang Akar GRM in the North Musi cluster area show a coarsening upward pattern of parasequences in GNY and DPT well interpreted as pro delta -delta front, but in M18 and M21 (Mambang Fields) show serrated pattern interpreted as fluvial floodplain Fig. 4. The sedimentation provenance of Talang Akar GRM originated from Sebakul high and Musi high.

Paleocurrent were inferred from the cross-bedding dips azimuth after Structural Dip Removal (SDR). As indicated in the rose diagram or fan plot below, overall paleocurrent shows multi-directional pattern, towards Northeast and South Fig. 5. aligned with the TAF GRM sedimentation source dominantly originating from Sebakul High in the northwest and then transported to the south and also originating from Musi High and then transported to northeast.

Based on the stacking pattern and the vertical relationship of the interpreted depositional environments, the studied interval could be divided into two (2) system tracts, Transgressive System Tract and Lowstand System Tract.

Sweetness attribute which was sliced at Talang Akar GRM interval, shows high anomaly amplitude as a sand lithology, guiding depositional environment interpretation. Mambang Field interpreted as fluvial floodplain which matches appropriately with Gamma Ray log with serrated type and a low anomaly sweetness attribute.

DPT well interpreted as a Delta Front-Mouth Bar-Distributary Channel deposits in a supralittoral environments with provenance dominantly from Sebakul High to the North confirmed through paleocurrent analysis and sweetness high anomaly amplitude, which is mean sandy interval of Talang Akar GRM Fig. 6 and seismic composite, which is flattening at upper Talang Akar to see Talang Akar GRM deposition Fig. 7. Based on biostratigraphy analysis from DPT well, the age of Talang Akar formation is suggested to be N3 or older which is based on palynology fossil found that is deposited in a supralittoral environment [10].

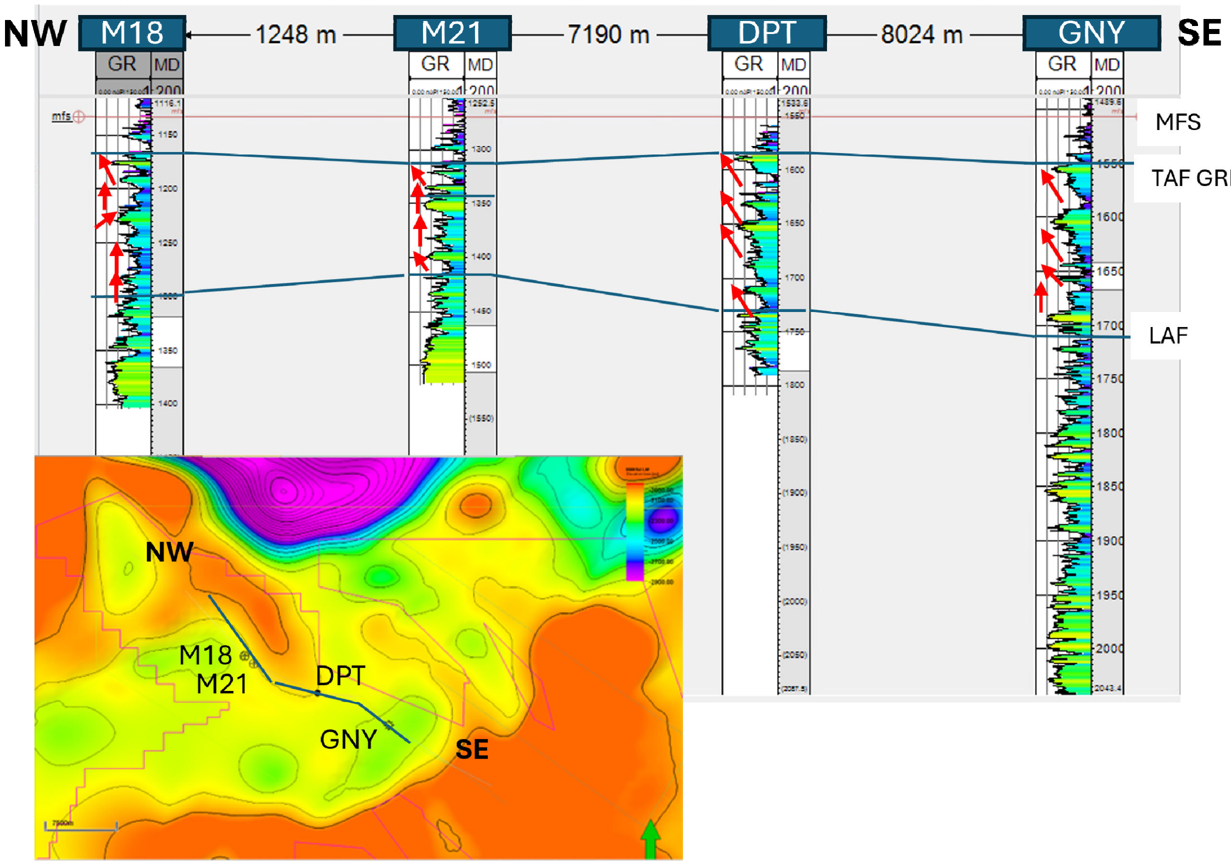


Fig. 4. Stratigraphic correlation from NW–SE.

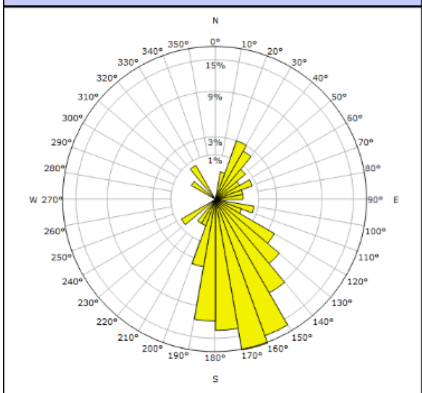
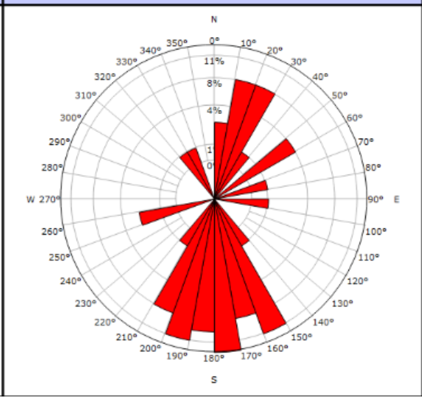
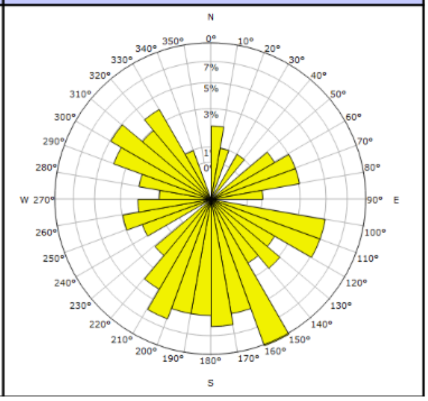
Before Structural Dip Removal (SDR)	After Structural Dip Removal (SDR)	
Sand Dips	Cross-Bedding Dips (Dip magnitude >10deg)	Sand Dips (Dip magnitude <10deg)
		

Fig. 5. Structural Dips [6].

Moreover, GNY well interpreted as Delta Front-pro Delta deposits in a supralittoral environment with provenance dominantly from Musi High at Southeast confirmed through sweetness high anomaly amplitude Fig. 6 and seismic composite Fig. 7. Overall, this analysis can predict the future development of the DPT well and future exploration target based on sweetness attribute mapping.

In conclusion, Talang Akar GRM in North Musi Cluster, South Sumatra Basin is deposited in a transgression system tract and low stand system tract. The sedimentation provenance comes from Sebakul high in the northwest and Musi High Platform in the southeast.

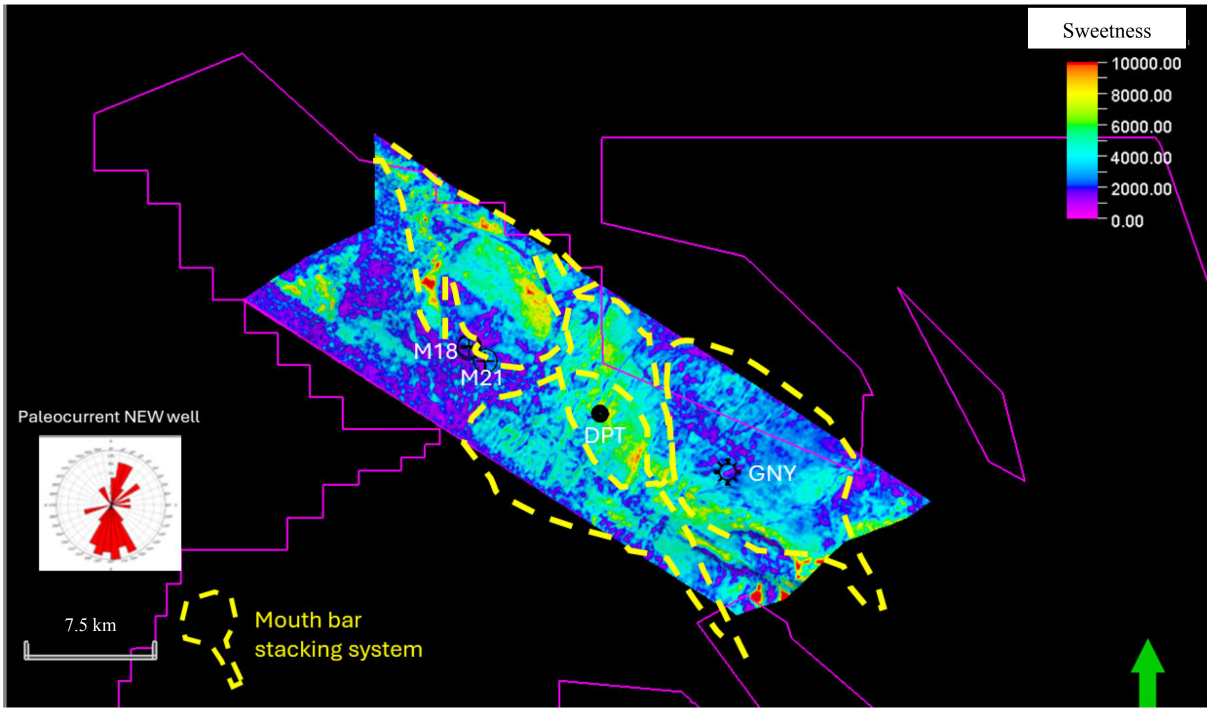


Fig. 6. Sweetness attribute slicing at Talang Akar GRM with paleo flow North-South direction.

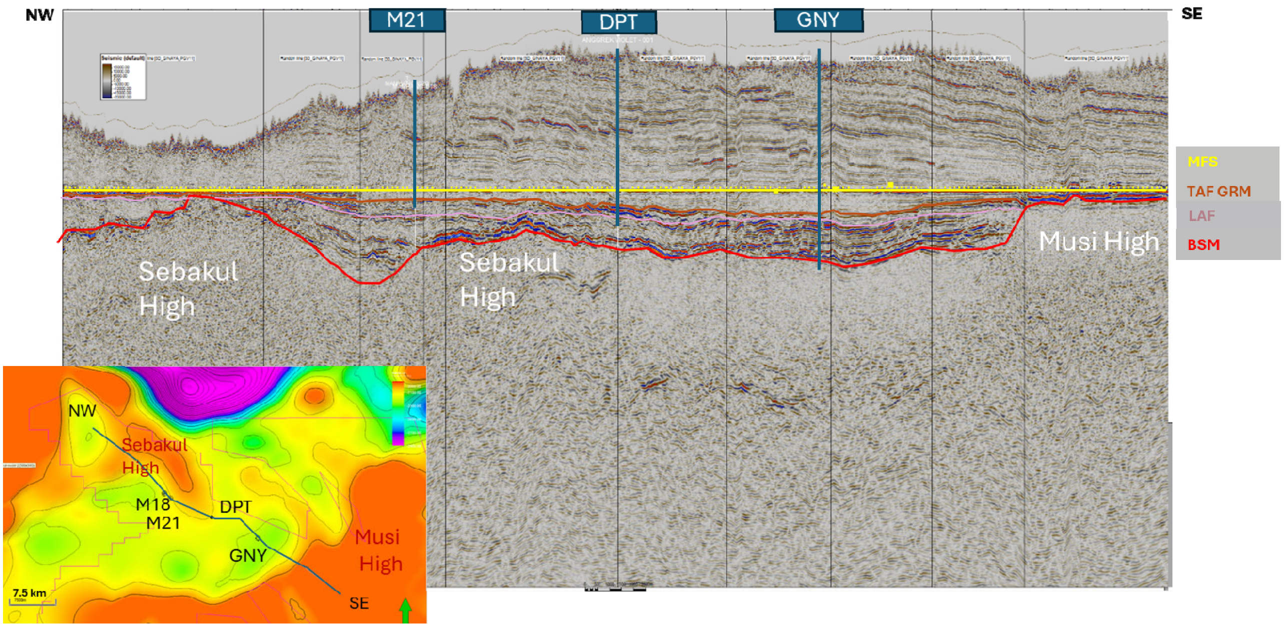


Fig. 7. Seismic composite with isopach of basement as a basemap.

Talang Akar GRM in North Musi Cluster is interpreted as mouth bar, pro delta -front delta deposits proven through GNY and DPT wells, which indicates the provenance to be from Sebakul high and Musi platform. Further evidence comes from Mambang field area which shows evidence of fluvial floodplain deposits and shows provenance coming from Sebakul high based on sweetness seimic attribute and borehole image interpretation.

Overall, the discovery from the DPT well exploration is poised to rejuvenate oil and gas exploitation in the North Musi Cluster, which has remained inactive since the cessation of production at the Mambang field in 2005. This study significantly enhances our understanding of TAF GRM facies distribution within the North Musi Cluster area and identifies promising stratigraphic play opportunities for TAF GRM as a future exploration target. The analysis highlights high anomaly amplitudes indicative of favorable conditions north of the Mambang Field and east of the GNY wells. Moreover, this research provides valuable insights for the development of the DPT well and the entire North Musi cluster. Lastly, the study should serve as a valuable analog for stratigraphic plays in other areas.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Khubbi has created the gamma ray log well correlation, Dwipaningtyas, Sigit, Syah Jenie has reviewed borehole image interpretation, biostratigraphy analysis, run sweetness attribute and integrated them into one geological model of Talang Akar GRM in North Musi Cluster. All authors has approved the final version.

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