Unleashing the unseen reservoirs via high resolution strata-slicing approach: An Insight on the upside potential of Stratigraphic Play in the North Malay Basin, Offshore Peninsular Malaysia.

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Summary

Identifying new opportunities in the Malay Basin is challenging as heavy exploration activity has taken place with more than 700 wells drilled since 1969. Nonetheless, Yet-to-Find (YTF) estimation in 2021 indicates around 3 Bboe of remaining potential are awaiting to be explored. This paper describes the utilisation of specialised seismic interpretation technology in combination with high resolution strata-slicing, as an alternative approach in identifying exploration potential within North Malay Basin. The geological nature of the NMB reservoirs comprising lower coastal plain channelised system, provides an ideal geological setting to test this application. More than 400 horizon strata slices were generated from the top of basement to the seabed using merged 3D seismic data obtained from Relative Geological Time (RGT) model using PaleoScan™ software. The strata slices are then used for amplitude attributes extraction and spectral decomposition analysis, in combination to interpret the geomorphological features and define it's associated geobodies where approximately 250 prospects were identified. One of the largest prospects yield a gas-initially-in-place (GIIP) of up to 2 Tscf. These findings are dominantly represented by fluvial channels within Groups F to I, which provided a new insight in a relatively mature basin.

Introduction

The Malay Basin has been heavily explored with more than 700 wells drilled since its first discovery in 1969. Nonetheless, from the 2021 YTF analysis, it is estimated to hold an approximately 3 Bboe of remaining potential within the basin. This study focuses on the NMB, which is dominantly gas prone and relatively less explored compared to the rest of the basin. The geological environment of the NMB reservoirs comprising lower coastal plain channelised system, provides an ideal setting to further test this methodology. More than 400 horizon slices were generated above the basement to the seabed utilising the merged 3D seismic data using PaleoScan™ seismic interpretation software. These generated horizon/strata slices over each seismic reflectors, obtained from RGT model are used for amplitude attributes extraction such as envelope, RMS and sweetness to map and delineate geological features within the area of interest. These products are integrated with spectral decomposition analysis to better constrain and interpret the anomalies geomorphology that defines the geobodies, estimated about 300 channelised features identified.

Methodology

This study utilises three-dimensional seismic interpretations to evaluate and identify the untapped hydrocarbon resources in the existing producing fields within the NMB by using the Malay Basin seismic groups which are defined through the occurrence of nannofossils that are present within the area (Morley et.al, 2021).

Analysis work is conducted using the seismic interpretation software, PaleoScan™ whereby generating the GeoTime model for the seismic data is a critical step in the workflow. Unlike the conventional horizon interpretation, the semi-automatic interpretation conducted in the "Model Grid" module. The process to generate the 3D Relative Geological Time (RGT) model starts with the generation of model grid, then refinement of model grid before generating the RGT model. The details on the workflow can be described in three steps, as shown in Figure 1. Based on the finalized RGT model framework, a stack of horizons was generated throughout the seismic volume via an iso-proportional strata slicing process, which focused on the top intervals of the seismic groups. More than 400 horizons were generated throughout the seismic volume for the succession of Groups AB to K where the number of horizon slices per interval differs depending on their thickness.

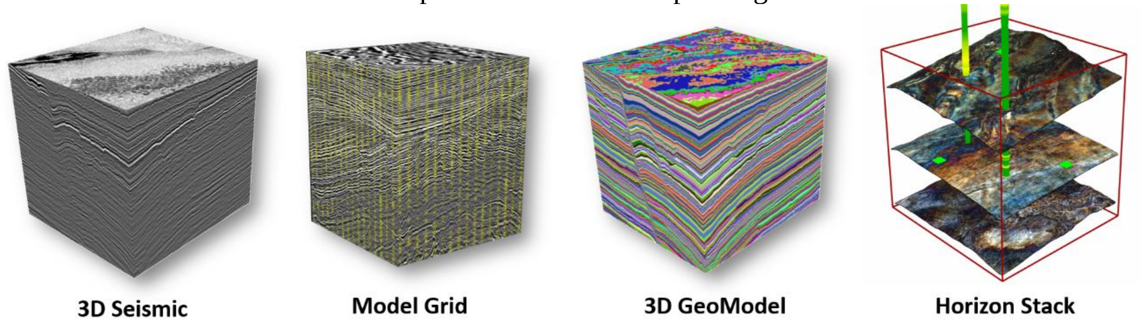

Figure 1 *The general workflow of PaleoScan™ seismic interpretation software starts with model grid generation and refinement to produce the 3D GeoModel which is used as input for horizon stack generation*

Several attributes analysis (i.e. RMS Amplitude, Envelope and Sweetness) are applied in order to enhance the visualization of the horizon stack generated. Further spectral decomposition methods are also implemented using spectrogram to define the best frequencies for each seismic group. Based on the seismic amplitude response results via horizon stack for each seismic group, PaleoScan™ is also able to identify a series of anomalies that could be related to sedimentological bodies representing coastal plain environment, ranging from fluvial to shallow marine settings.

Identified potential prospects were extracted as geobodies from the horizon stack and underwent volumetric assessment to assess its prospectivity. These prospects were ranked according to its individual volumetrics and their corresponding stacking possibilities.

Results

Group D is interpreted to be in the lower coastal plain environment with tidal influence (Morley et al., 2021), corroborated by the geological features identified, comprising of channel belt and channel distributaries. The big channel belt observed at shallower sections (Figure 2A & 2B) comprise of multiple, low amplitude channels bounded by normal faults. The depositional direction is interpreted to be originated from the basement high in western flank (Alqahtani et al., 2017 & Kuenphan et al., 2010) that fed into the basin centre. Nonetheless, further studies are needed to verify this observation. Reservoir sands presence analysis on the meandering channels encompassed in the main channel belt are thought to possess huge potential for future exploration target. On the other hand, Figure 2C shows a low amplitude distributary channel sourcing from the north-east direction towards the centre of the basin.

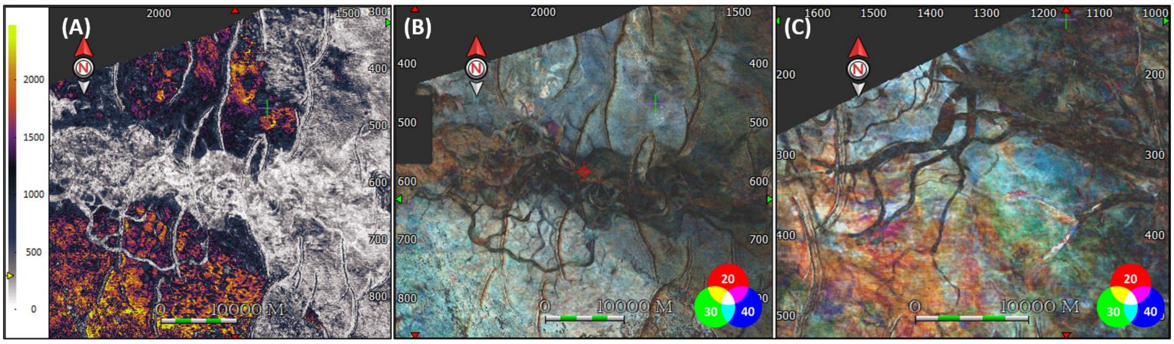

Figure 2 *(A) RMS attribute showing the channel belt in Group D. (B) Spectral Decomposition of the channel belt. (C) Distributary channel feeding toward the central of the basin.*

The depositional environment of Group E changes from a fluvial environment to an upper delta plain which can be correlated to the biostratigraphic marker SEA59C, suggesting a sea-level rise in the early stages (Morley et al., 2021). A significant low amplitude channel was observed at the centre of the basin toward the southern part between base of Group D and top of Group E of the study area (Figure 3). This channel belt is thought to have emerged from the eastern flanks and flowed into the centre of the basin, as indicated by low amplitudes due to the masking effect of surrounding coal deposits.

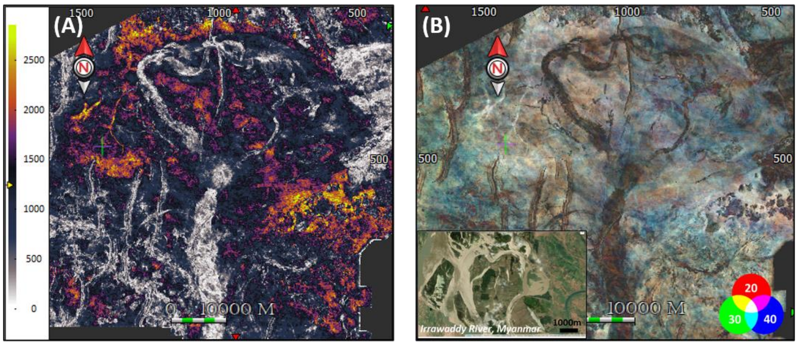

Figure 3 *(A) A low amplitude channel observed at the central part of the basin on the RMS attribute map. (B) A modern analogue of Irrawaddy River, Myanmar is identified to portray the same geometry as the channel on the spectral decomposition.*

Group F lies in a paleoenvironment of deltaic-inner neritic to fluvial settings as approaching to shallower sections of base of Group E (Madon et al., 1999). This interval encountered a global sea level fall that eventually forms a fluvial-dominated environment (Morley et al., 2021). This is supported by the discovery of benthic foraminiferas to Rhizophora mangrove type pollen in Bergading Deep-3 well approaching seismic Group E. Findings suggest a channel complex on the eastern flank of the basin with several interpreted point bar features (Figure 4A). Within the similar horizon strata slicing, another channel complex is identified near the basin centre, where a combination of low sinuosity and meandering channels are present within the same channel complex (Figure 4B).

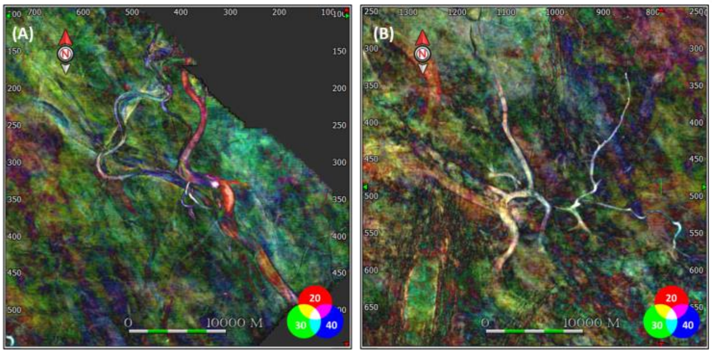

Figure 4 *(A) High sinuosity channel complex observed within Group F.*
(B) Low sinuosity meandering channel complex of Group F

In the deeper intervals of Groups H and I, the depositional setting is characterised by lower coastal plain environment, with abundance of fluvial channels observed throughout the study area. A noteworthy discovery at Group H reveals a widespread occurrence of channels positioned at both western and eastern flanks with additional channels present at the basin centre (Figure 5A). The channels presence in Group I are observed to be concentrated at the eastern flank with minor appearance in the central region. The general characteristic of Group I channels are its relatively large sizes with low to high sinuosity. Those associated point bars are common in high sinuosity channels. In the shallower sections of Group H, the channels identified are comparably smaller to Group I with similar sinuosity. The point bars can be potential prospects focus as stratigraphic traps (Figure 5B).

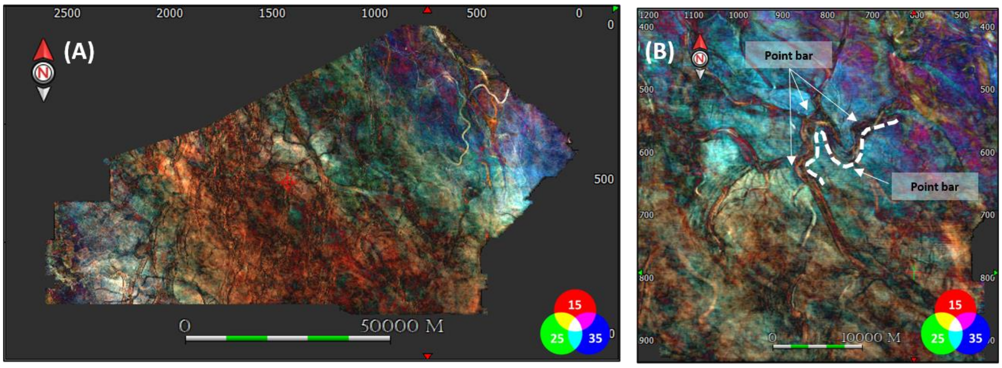

Figure 5 *(A) Fluvial channel events in Group H occurring widespread in the study area.*
(B) Meandering channel associated with point bar deposits.

The high-resolution strata slicing enabled the complexity of subtle channel events occurring in Group I to be detected and captured. Amongst the channel complex delineated, a large scale, low amplitude channel belt located at the basin centre can be observed in Figure 6A, whilst the eastern flank reveals a high amplitude channel within the spectral decomposition analysis (Figure 6B). A high amplitude response within the Group I was interpreted as crevasse splay from an overbank deposit in part of the meandering channel (Figure 6C).

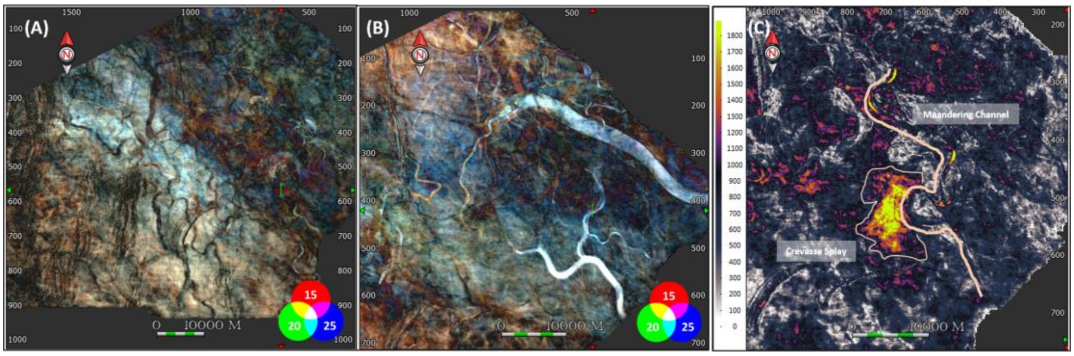

Figure 6 *(A) Large scale, low amplitude channel belt located at basin centre. (B) High amplitude channel within the spectral decomposition analysis. (C) Bright amplitude interpreted as crevasse splay.*

Conclusions

Potential reservoirs not identified previously, are now evaluated and visualized utilising advanced semi-automatic method of Relative Geological Time (RGT) model, and its subsequent high resolution strata slicing technology through PaleoScan™ software and associated methodologies. The iso-geological surfaces derived from the horizon stack revealed subtle stratigraphic features that consist of various fluvial depositional geomorphologies such as point bars, crevasse splays and distributary complex in the lower coastal plain settings. These features are subsequently extracted as geobodies, and assessed for volumetric calculation both as individual prospects and multi-stack potentials. It is noteworthy that current volume evaluation has yet to account for the petroleum system elements risking analysis. About 300 channelized bodies were extracted that are dominantly represented by fluvial channels in Groups F, H and I. This study has successfully identified approximately 250 new prospects that will be further refined to upgrade the YTF of the Malay Basin and open up new discoveries in the future to support energy security in Malaysia.

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