Introduction

The North Sumatra Basin has a long history of hydrocarbon exploration, with numerous discoveries concentrated in onshore and shallow offshore settings. In contrast, the deeper offshore region has remained relatively underexplored, largely due to historically poor subsurface imaging, complex structural styles, and limited well control at depth. Recent advances in seismic acquisition and processing, particularly broadband 3D seismic technology, have significantly improved imaging of deep basin architecture and petroleum system elements.

Recent exploration success in the basin demonstrates that the Paleogene syn-rift interval represents a viable and underexplored play in the deeper offshore domain. This study presents an integrated seismic interpretation of a largescale broadband 3D and reprocessed 2D seismic surveys over the Pase sub-basin, highlighting how improved seismic imaging has reduced geological uncertainty and enabled confident pursuit of Paleogene syn-rift plays.

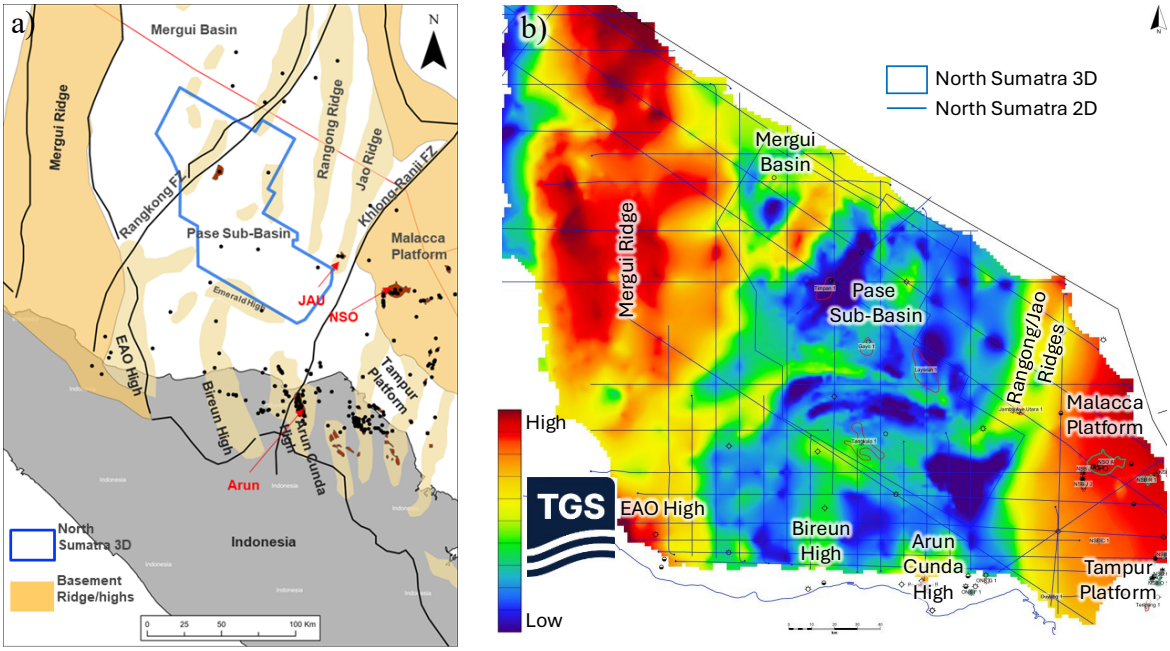


Figure 1 *Comparison of pre existing generalised structural framework with high resolution mapping now possible utilising modern broadband data.* ***a)*** *Regional tectonic framework of the North Sumatra Basin showing basement highs and sub basin segmentation.* ***b)*** *Basement TWT Structure mapped on new Broadband 3D and reprocessed 2D seismic data*

Geological Setting

The North Sumatra Basin is a Tertiary extensional basin developed on Pre-Tertiary to Cretaceous Sundaland basement. Basin evolution was controlled by regional extensional tectonics, resulting in a series of N–S trending basement highs and depocentres that segment the basin into multiple sub-basins (Figure 1). These structural elements exert a strong control on syn-rift sedimentation patterns, accommodation space, and petroleum system development.

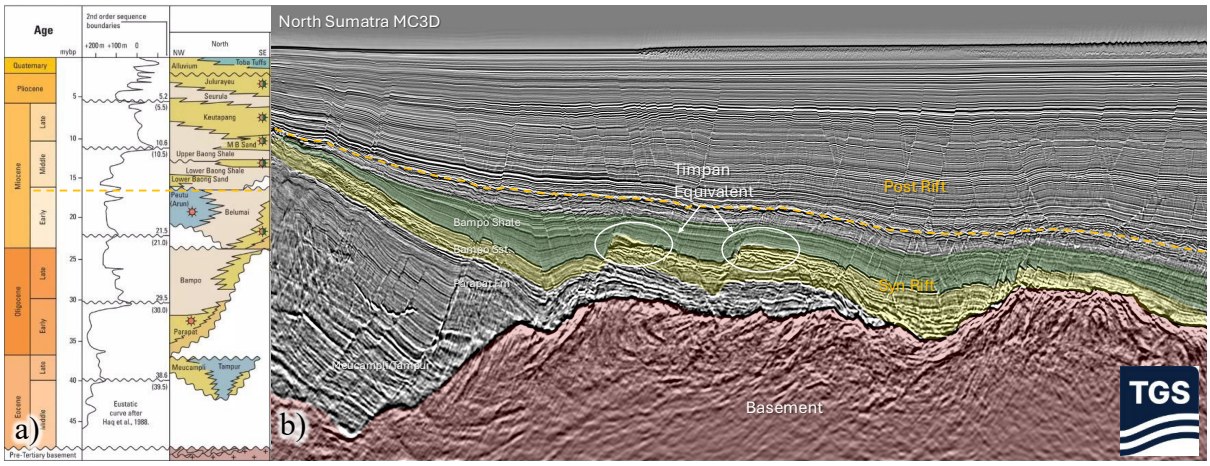


Figure 2 ***a)*** *Chrono stratigraphic chart for North Sumatra Basin (After Alexander & Nellia 1993, Fainstein 1996, Riadhy et al1 1998 in: Netherwood 2000)* ***b)*** *Geo-seismic section illustrating Paleogene graben geometry and correlation to the general stratigraphy of the North Sumatra Basin.*

The extent of exploration varies significantly across the basin. Onshore areas and the shallow offshore Tampur and Malacca platforms are considered to be well explored, with discoveries primarily in the post-rift Neogene (such as the Arun carbonates). The deeper offshore domain, including the Pase sub-basin, has historically been considered frontier, with limited understanding of syn-rift stratigraphy and trap development due to poor seismic resolution at depth

Data & Methods

This study is based on interpretation of multiclient broadband reprocessed 2D combined with approximately 9,000km^2 of new 3D seismic acquired in 2018, covering the Pase sub-basin. The broadband acquisition and reprocessing significantly enhanced both low and high-frequency content, resulting in improved vertical resolution and deeper imaging compared to legacy seismic datasets (Figure 3).

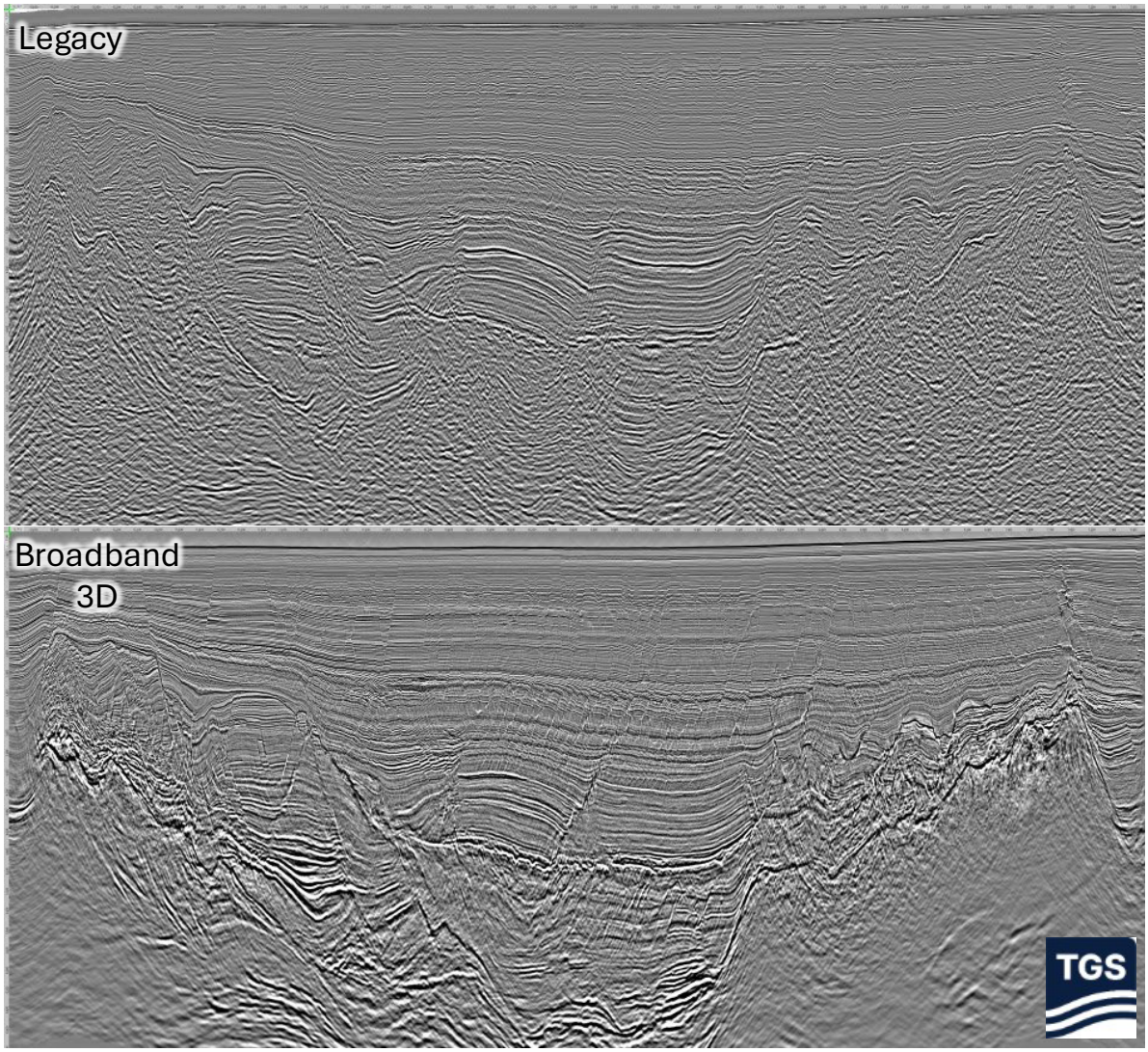


Figure 3 *Comparison between legacy data and newly acquired Broadband 3D.*

The 3D seismic interpretation was integrated with reprocessed regional 2D seismic data to provide basin-scale structural and stratigraphic context (Figure 1b)

Seismic interpretation focused on mapping key tectonostratigraphic horizons, major fault systems, and syn-rift depositional geometries. Structural styles, half-graben geometries, and syn-tectonic thickness variations (isochrons) were analysed to better understand the burial history & petroleum systems source kitchens and trapping mechanisms. Depth converted seismic sections were used to assess structural closure, trap integrity, and potential hydrocarbon charge indicators.

Results

Interpretation of the broadband 2D and 3D seismic data reveals a well-developed syn-rift structural framework within the Pase Sub-basin. Multiple half-graben systems are clearly imaged, bounded by major normal faults and containing thick Paleogene–Oligocene sedimentary successions (Figure 4). These syn-rift depocentres form the deepest offshore portions of the basin and were previously poorly resolved on legacy seismic data.

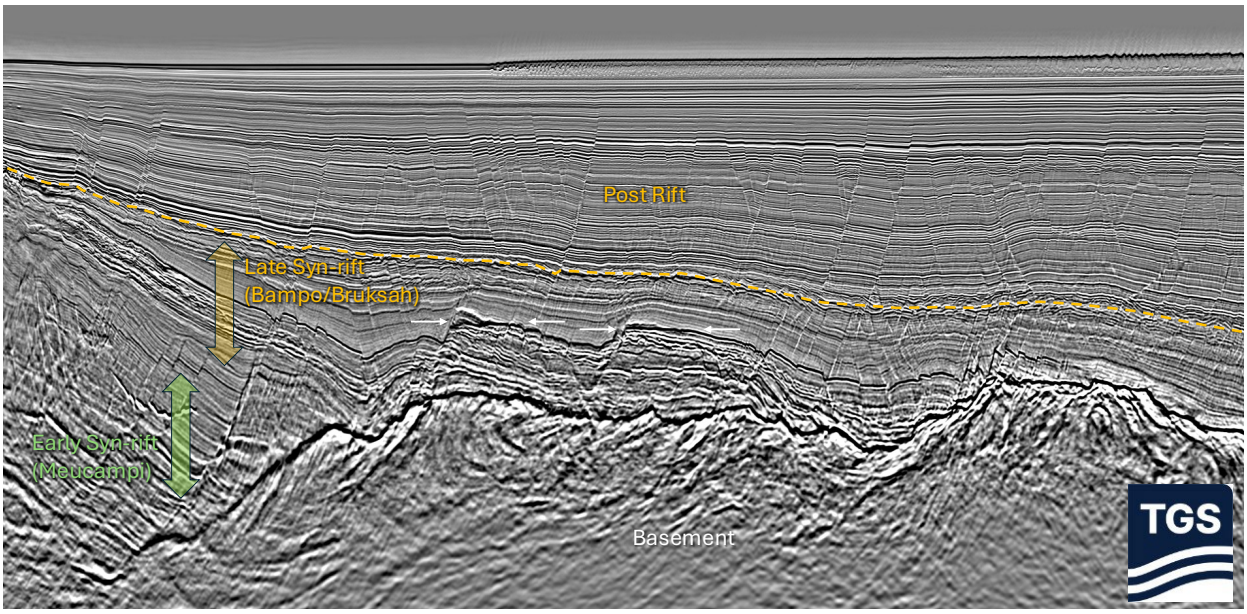


Figure 4 *Seismic section from the North Sumatra MC3D showing syn-rift structural closure with interpreted Direct Hydrocarbon Indicator (undrilled flat spot).*

Numerous structural closures are identified at the top syn-rift level. These closures are typically associated with fault-bounded tilted blocks and rollover geometries. The play-opening discoveries of Timpan-1 and Layaran-1 display seismic amplitude anomalies consistent with Direct Hydrocarbon Indicators (DHIs), and several additional look alike structures with flat spots are now observed on seismic sections (Figure 4).

Subsequent discoveries such as Tangkulo-1, confirm the presence of an effective source to reservoir petroleum system within the syn-rift interval. These discoveries validate the interpreted play concept across the Pase sub-basin and significantly reduce geological risk in the deeper offshore.

Discussion

The results demonstrate that the Paleogene syn-rift interval represents a robust exploration play in the deeper offshore North Sumatra Basin. Improved broadband seismic imaging has been critical in resolving complex fault geometries, stratigraphic thickness variations, and DHIs that were previously obscured.

While exploration maturity remains low in the deeper offshore domain, recent discoveries substantially enhance the attractiveness of the syn-rift play fairway. Integration of 3D and regional 2D seismic data enables confident extrapolation of play elements beyond drilled locations, supporting further prospect maturation and acreage evaluation.

Conclusions

Broadband 2D and 3D seismic imaging has fundamentally improved understanding of the deep offshore North Sumatra Basin and enabled confident opening of Paleogene syn-rift plays. Key conclusions are:

- The basin contains well developed syn-rift half graben systems with thick Paleogene- Oligocene successions.
- Multiple structural closures with Direct Hydrocarbon Indicators are identified at syn-rift level.
- Recent discoveries validate an effective source to reservoir petroleum system.
- Improved seismic imaging has significantly reduced subsurface uncertainty and exploration risk.

These results provide a strong technical foundation for continued exploration, seismic acquisition, and prospect maturation in this frontier offshore domain.

References

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