

ICE: 4550848

Integrated Seismic and Stratigraphic Insights into the Depositional Framework of the Kutei Basin

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This paper was prepared for presentation at the AAPG International Conference and Exhibition (ICE) held in Jakarta, Indonesia, 07-09 December 2026.

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Summary

The Kutei Basin is located to the east of Borneo in Kalimantan, Indonesia. The basin covers an extensive onshore area and extends offshore into the deepwater Makassar Straits to the West Sulawesi coast. The basin is the largest in Indonesia and a highly prolific petroleum province. Recent discoveries such as Geng North-1, Gehem, and Gendalo-Gandang, now part of the Northern Hub development, underscore both its productivity and remaining potential, with recently announce Geligna-1 continuing to cement the success in the area. While large areas are deemed mature, the deepwater remains underexplored, but advances in seismic imaging alongside regional integration with geological interpretation opens up new opportunities.

This study develops a regional depositional framework using integrated geophysical data and an extensive well dataset. A central element is the transformation of 119 vintages of 2D seismic (1969–2019) into a single “2D^{cubed}” volume covering 73,000 km², alongside modern 3D datasets, providing a consistent platform for structural and stratigraphic interpretation. Calibration with 62 exploration and appraisal wells ensures robust geological control.

Well analyses, including sequence stratigraphy, chrono- and lithostratigraphy, facies interpretation, and gross depositional environment (GDE) analysis, were integrated into the seismic interpretation. Inputs include cuttings, core data, correlations, seismic facies, and biostratigraphy, synthesised into calibrated facies and regional GDE maps across key petroleum system intervals.

Results reconstruct the basin’s sedimentary history from the Late Eocene to Early Pliocene, defining depositional fairways, sediment influx, and deepwater connectivity. This highlights key stratigraphic intervals and delineates potential fairways in underexplored areas, as well as identifying prospectivity.

The study demonstrates that mature hydrocarbon provinces can yield new insights through innovative use of legacy data. While modern seismic provides quality control and refines the depositional model, integration with legacy 2D datasets demonstrates that the Kutei Basin retains significant untapped potential, particularly in underexplored deepwater domains.

Introduction

The Kutei Basin is located on the east coast of the large Kalimantan Island, in central Indonesia. The Kutei Basin formed during Middle Eocene E–W extension, with syn-rift sediments deposited in grabens and half-grabens, ranging from alluvial fan to marine environments. By the Late Eocene, most of the basin was marine, with isolated carbonate build-ups on basement highs.

Extension largely ceased by the end of the Eocene, marked by a regional unconformity. From the Oligocene, post-rift thermal subsidence dominated. Late Oligocene hinterland uplift initiated proto-Mahakam Delta deposition. Basin inversion began in the Early Miocene, peaking in the Middle Miocene, driving uplift, erosion, and progradation of sand-rich deltaic facies.

A further Upper Miocene inversion enhanced progradation and initiated slope turbidite deposition. Toe-thrusting developed in the northern slope, while gravity-driven extensional faulting formed deepwater structures.

The collision of the Sulawesi Blocks led to a volcanic-cored province to the east, followed by westward thrusting and the formation of the offshore West Sulawesi Fold Belt.

The basin ranks as one of the most mature exploration provinces globally, with a history extending over 130 years. Exploration began with the discovery of the Sanga Sanga oil field in 1896, before progressing offshore in the 1970s, resulting in major Miocene deltaic gas discoveries in the Mahakam Delta (e.g. Handil, Badak, and Tunu). Recent exploration successes, including Geng North-1, Gehem, and the Gendalo–Gandang accumulations within the Northern Hub development, reaffirm the continued productivity of the Kutei Basin and highlight the presence of significant remaining hydrocarbon potential.

The remaining potential and the access to the huge volume of integrated seismic data, as well as the open file access to the well data, act as a motivator for this large-scale regional study, where the stratigraphic framework can be revisited and the depositional environment over time reviewed from first principles.

Method

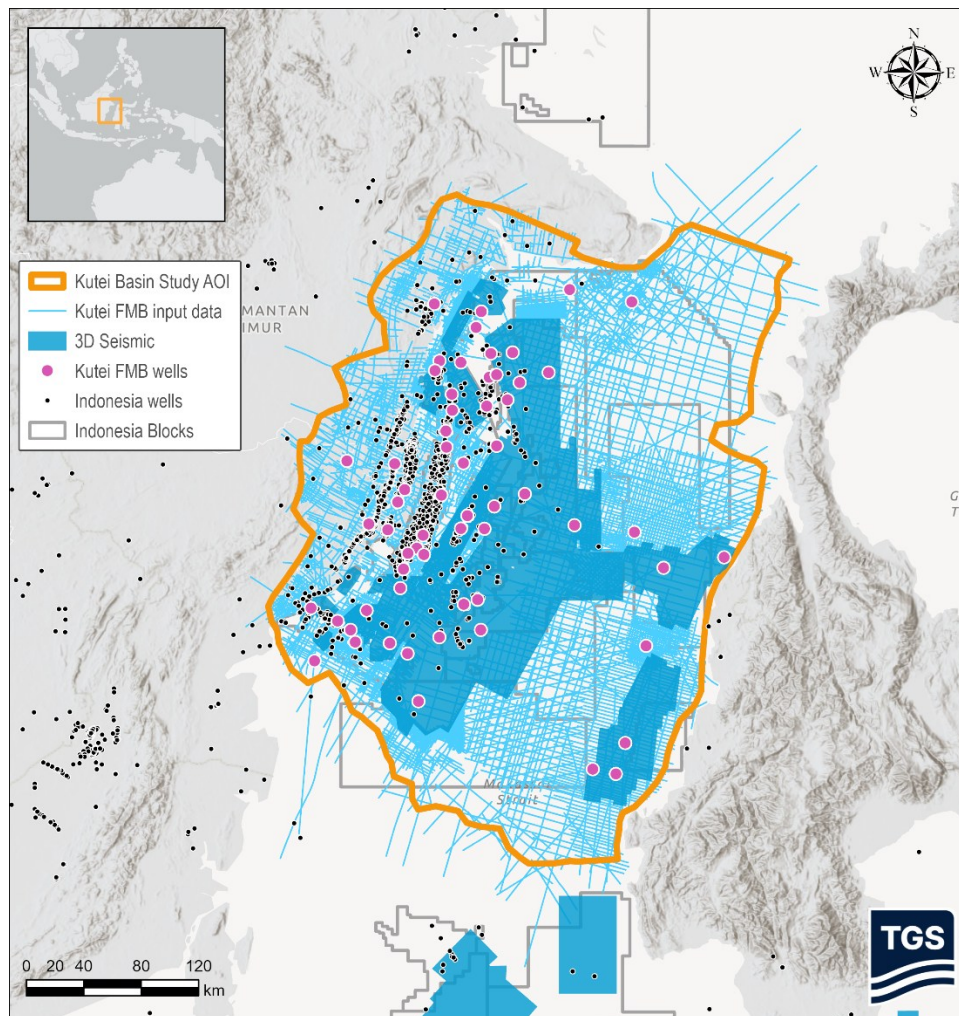


Figure 1 Kutei Basin study area, including project data such as wells (pink well spots), 2D & 3D seismic data (blue) within the AOI (gold polygon) that form the study database

Figure 1 shows the vintage seismic data, which was accessed as part of this project; it was then transformed into a continuous dataset. $2D^{cubed}$ is a seismic processing technique that enables regional interpolation of 2D seismic data by guiding interpolation along 3D geological horizons derived from 2D dip fields and layered geological models. This approach allows reliably bridging kilometre-scale gaps between 2D seismic lines whilst overcoming limitations of conventional interpolation methods where the density of the $2D^{cubed}$ input data varies due to historical exploration focus (Whiteside et al., 2013).

This 3D seismic volume enabled interpretation of key mega-sequence intervals across the project area, (Figure 2) with specific focus on the Eocene to Late Miocene, and established a robust structural framework for consistent well ties at the regional scale.

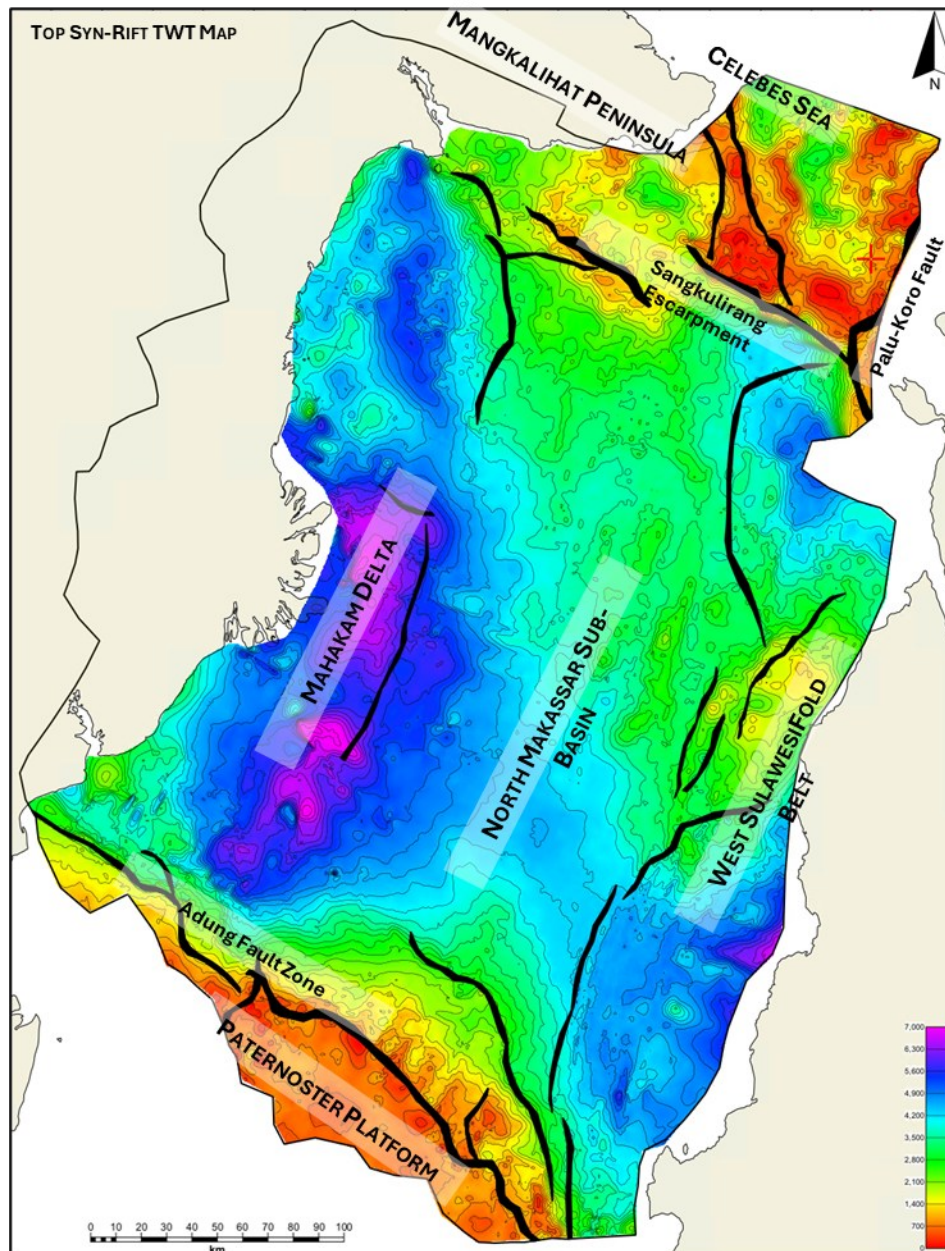


Figure 2 TWT map interpreted on the regional dataset showing the depth to top syn-rift and the key faults and provinces

The wells shown as pink dots in Figure 1 were selected for the project based on their geographic spread, depth of penetration and data availability. A detailed lithological modelling workflow was undertaken using a combination of rock data derived from cutting descriptions, core and interpreted descriptions from biostratigraphic reports and log responses (Rider and Kennedy, 2011).

Following the lithological interpretation, an initial stratigraphic framework was developed and iterated with more in-depth well-based interpretation, integrating all available data and previous interpretation stages to establish chronostratigraphic, lithostratigraphic, and sequence stratigraphic tops. These well-based facies interpretations, when combined with the seismic data allow for the development of high-resolution GDE maps, as show in Figure 3

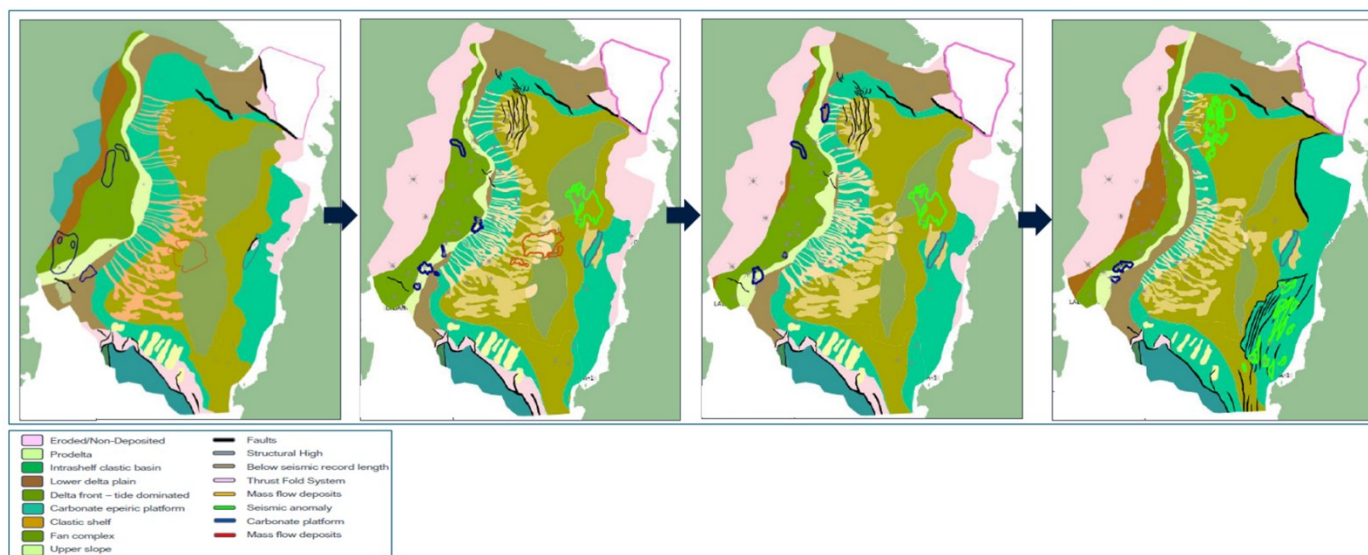


Figure 3 Example GDE maps showing the evolution of the basin from the oldest on the left to the youngest to the right

Results

With a fully integrated study, combining the latest seismic data in the region with a consistent comprehensive stratigraphic interpretation of the wells across the whole region we can start to make observations on features such as sediment pathways into the Mahakam Delta system (Figure 3) during the Early Miocene. Key observations on the timing and evolution of the carbonate generation phases on highs and the palaeo-shelf breaks and understanding the timing of the peak sedimentation phase observed in T100 sequences (Upper Miocene) are invaluable to the continued prospectivity of the mature plays. Comprehensive regional mapping of the deeper basement and syn-rift structural development has enhanced the potential for both older immature plays to be further tested, but also to understand the deposition and distribution of key deeper-water plays off the delta shelf. Principally, this work has highlighted areas where lowstand sands derived from the main delta have continued into deeper water and pooled between structures and contourites formed by deepwater currents.

Discussion

Future work in the region can be enhanced through the integration of more recent seismic volumes enabling a finer GDE map resolution, and additional wells enabling greater calibration on the fairway mapping process. New exploration wells are being drilled in the main delta with a renewed exploration focus currently ongoing and incorporating those will further develop the understanding as well as potential for new seismic acquisition in the complex northern area as well as the fold and thrust belt.

Conclusions

The study has provided a regionally consistent and updated stratigraphic framework for the area as well as several GDE maps which can be used to predict reservoir fairways for exploration or CCS purposes. During the study, a number of potential prospects at several stratigraphic levels have been highlighted, adding promise to an already key province. Despite the maturity of the main play in the Kutei Basin, recent wells and integrated workflow such as this highlight the huge potential for secondary plays to rejuvenate a mature province.

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