Interactive Approach of Semi-Automated 3D Seismic Interpretation: Insights from DW Sabah Basin, Offshore Sabah

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Summary

For decades, technology has been introduced for interactive seismic interpretation in order to assist geoscientists to interpret seismic volume comprehensively and time-saving approach. Semi-automated interpretation has been developed to enhance the regional geological understanding particularly at reservoir level. The studied sedimentary basin lies within northwest (NW) Sabah offshore, which evolves during the Late Cretaceous period. NW Sabah Basin consists of post-early Middle Miocene sequence which overlies West Crocker Formation (Oligocene – Early Miocene) and younger Rajang Group rocks. Deepwater (DW) Sabah stratigraphy covers from syn-rift to post-rift intervals, separated by Middle Miocene Unconformity (MMU). The interpreted normal fault at syn-rift interval corresponded to extensional episode while thrust fault on the post-rift interval are resulting from regional compression. The study conducted by performing structural interpretation, horizon mapping and attributes analysis by applying the semi-automated interpretation workflow. Driven by the Relative Geological Time (RGT) model has enabled the sequences and the regional prominent key horizons of Sabah Stages to be generated, alongside with the attributes mapping and spectral decomposition. Based on the seismic attributes and geomorphology identified, the study area interpreted in the deep-water setting.

Introduction

Classical seismic interpretation has been applied for decades in order to interpret the seismic dataset for stratigraphic events. Remarkable efforts by numerous key players for the past few years has expedite the G&G evaluation processes especially on the interpretation pace. Semi-automated interpretation has been developed to enhance the regional geological understanding particularly at reservoir level. This study focuses on the application of semi-automated interpretation by using 3D Model-Grid and Relative Geological Time (RGT) Model methodology approach has perfected the classical workflow as to improve the geological interpretation on DW Sabah Basin, offshore Sabah.

The studied sedimentary basin lies within northwest (NW) offshore Sabah, which evolves during Late Cretaceous. It is bounded to the west by the West Baram Line, NW trending Tinjar strike-slip fault to the east by the Balabac Line. Sabah Basin consists of post-early Middle Miocene sequence which overlies West Crocker Formation (Oligocene – Early Miocene) and younger Rajang Group rocks. The basin evolves as a foreland basin, due to NW Sabah Platform – western Sabah collision during early Middle Miocene (Mazlan Madon et al., 1999).

DW Sabah stratigraphy covers from syn-rift to post-rift intervals, separated by Middle Miocene Unconformity (MMU). The study conducted by performing structural interpretation, horizon mapping and attributes analyses by applying the semi-automated interpretation workflow. The technique of interpretation applied for this study has resulted in RGT model creation. The RGT model then be used to generate horizon stack, which consists of multiple horizons interpreted from seabed to basement (Pauget et al., 2009).

Methodology

The 3D seismic interpretation workflow has two phases. The first phase consists of model grid computation and RGT model creation, using cost function minimization to calculate degree of correlation. The algorithm will use high correlation value which reflect the confidence factor to connect the nodes and interpret them as sets of links. These sets have been refined thoroughly to fit with regional geological understanding of the studied DW Sabah Basin. The regional key horizons are interpreted and used as constrained for RGT model refinement, subsequently. This workflow is crucial to ensure the RGT model is consistent with the geology of the study area.

The second phase of the workflow is the horizon stack generation, which is created from RGT model. This workflow enables the creation of preferred number of horizon slices throughout the 3D seismic volume. Once created, the horizon stack is mapped with basic attributes for structural interpretation, sedimentary and stratigraphical features identification. Spectral decomposition is applied afterwards to enhance and highlight the geological features such as structural features and sediment fairways.

Results and Discussion

The complex structural development of the DW Sabah Basin can be observed during the fault interpretation stage. Two types of faults are interpreted, normal fault on the syn-rift and thrust fault on the post-rift interval. Fault strike is showing NE-SW trends while dip direction is showing NW-SE trends with dipping angle ranging from $40^o – 80^o$. Syn-rift interval with interpreted normal fault exhibits half-graben structures, which supported extensional episode theory during Early Miocene. Thrust fault on the post-rift interval on the Sabah Fold Thrust Belt are resulting from collision, regional compression or subduction (Hall, 2013).

Four main sequences are picked, in reference to seismic response and biostratigraphical study. There are early syn-rift, late syn-rift and post-rift which can be divided into Early – Late Miocene Turbidite and Pliocene – Pleistocene Turbidite, respectively (Figure 1). Based on the driven RGT modelling from semi-automated interpretation, eight prominent regional horizons have been interpreted. By using Regional Sabah Stratigraphy scheme as a reference, isochore creation has been generated for Stage II, Stage III, and from Stage IV A until Stage IV F. Based on the creation, Stage II indicated that the sediment thickening can be observed particularly on the northwest of the DW Sabah Basin. From Stage IV A onwards, the sediment thickening can be seen on the southeast (Sabah Fold Thrust Belt) and thinning towards the deeper section of Sabah Trough. This indication shows that two source of sediment supply can be observed on the study area, Sabah Platform (south-eastward) and possibly onshore Sabah (north-westward). Attributes mapping have enhanced other geological features like submarine fans, mass transport deposits, ponded turbidites, carbonate buildups and pinnacles and slope deposits (Figure 2).

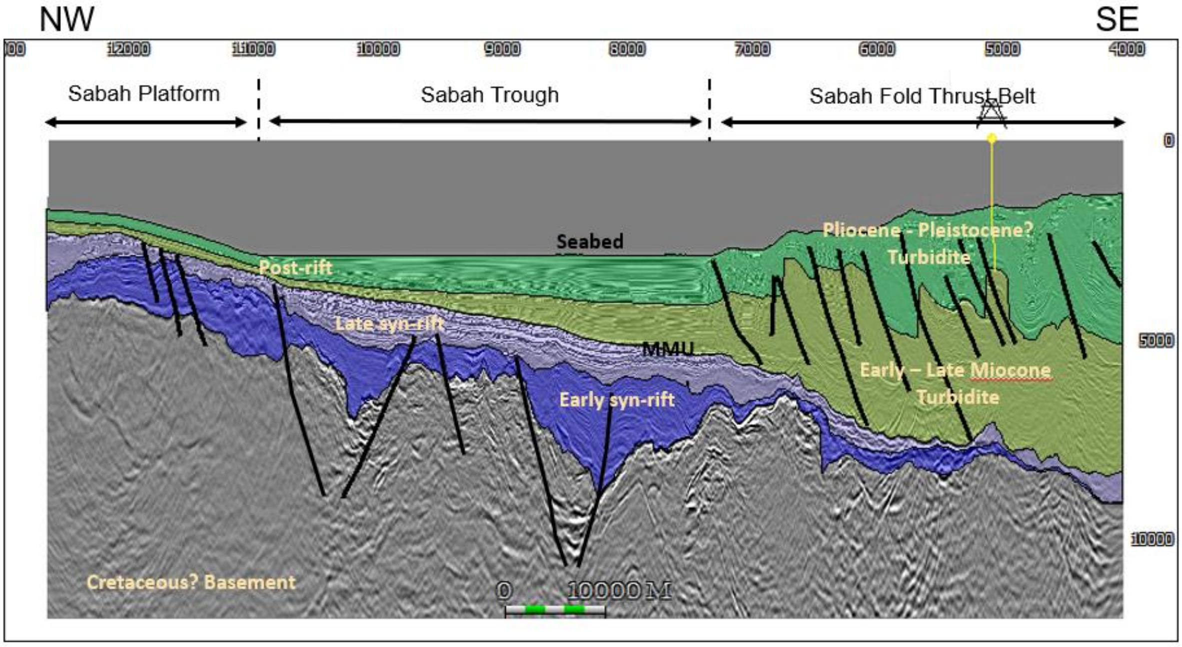

Figure 1 *Seismic section crossing from northwest to southeast of Sabah Basin, consisting of four sequences of early syn-rift, late syn-rift, Early – Late Miocene Turbidite and Pliocene – Pleistocene Turbidite. Both syn-rift and post-rift are separating by Middle Miocene Unconformity (MMU). Syn-rift observing normal fault due to extension while thrust fault on the post-rift interval is due to compressional episode. Horizontal and vertical scale is in meter (m).*

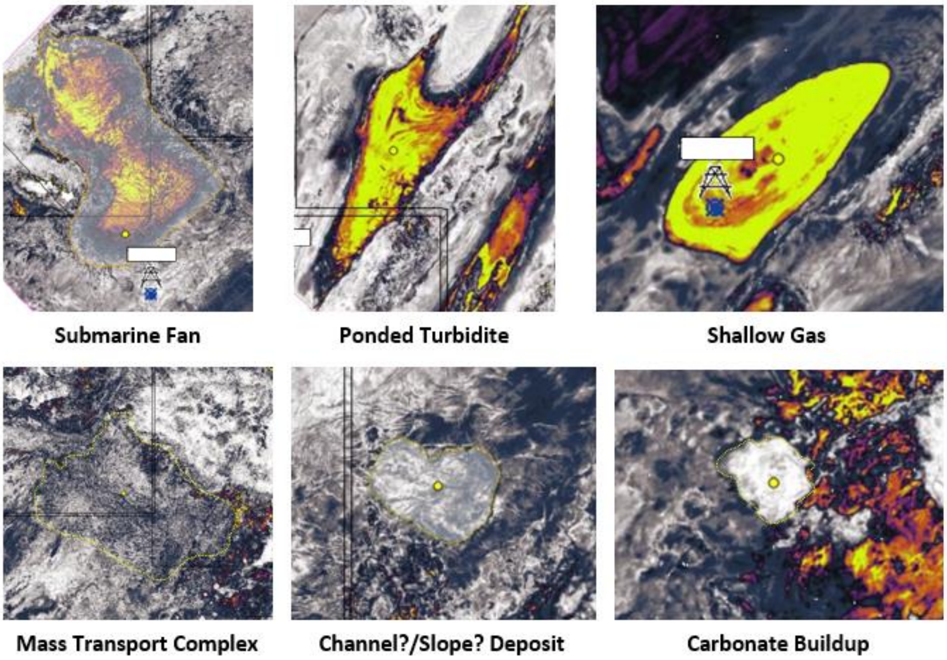

Figure 2 *Stratal slicing based on amplitude mapping derived from RGT model. These seismic attributes/geomorphologies were reflecting submarine fan, ponded turbidite, shallow gas, mass transport complex, slope? deposit and carbonate build-up, respectively. Most of these geomorphological features were deposited at the post-rift interval.*

Conclusion

The fault trends for DW Sabah Basin are showing NE-SW trends while dip direction is showing NW-SE trends with dipping angle ranging from 40º – 80º. The interpreted normal fault at syn-rift interval corresponded to extensional episode while thrust fault on the post-rift interval are resulting from regional compression. Isochore and attribute mapping indicate that two source of sediment supply can be observed, Sabah Platform (south-eastward) and possibly onshore Sabah (north-westward). An inclusive approach by using the workflow presented in this study has proven the advancement in seismic interpretation. Driven RGT model enables the sequences, and the regional prominent key horizons of Sabah Stages can be generated, alongside with attributes mapping and spectral decomposition which then supported that this study area has been interpreted as deep water setting, based on the seismic attributes/geomorphology that has been studied.

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