Warukin Deep - The Hidden Potential of Warukin Field, South Borneo: Untouched Reserves in Mature Field*

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Abstract

Since hydrocarbon discovery in Indonesia during early 20th century, the oil and gas are the main energy to support economy growth. The needs for oil and gas are growing while the reserves continue to decline. Many prolific oil fields are now considered mature fields. This becomes a challenge for oil and gas producers to improve the production and to find new prospects. In this study, analog play concept, geophysical analysis and data integration were used to unlock the prospects in a mature field.

Warukin Field, located in Barito Basin, South Borneo is one of the prolific oil fields that operated from late 1965, producing from the Middle Warukin Formation. The reservoir itself, is typical thick layered unconnected fluvial deltaic sandstones. The first discovery of this field is from exploration well drilled at WS-01 with 2767 barrels of oil. The following delineation wells drilled and obtain an Estimated Ultimate Recovery (EUR) 16.88 MMSTB. With cumulative production 13.01 MMBO and the remaining 3.87 MMBO from a total of 29 wells that has been drilled, the field is now considered as very mature field. The unconnected reservoir character in the existing production zones makes the IOR/EOR effort such as waterflood very difficult and may not be the best answer for increasing the production.

Following the success of Piraiba's exploration well (PRB-01, 2015) located about 19 km from Warukin Field proved that the Lower Warukin Formation also contains hydrocarbon. Recent geological and geophysical studies using analog models and integration of old and new data from Warukin and its surrounding fields shows there is hidden and untouched potential from a deeper zone, the Lower Warukin with reservoir characters' analogs to Piraiba's multi layered sandstone reservoir. The complex stratigraphy architecture of the Lower Warukin Formation has proven to be a good stratigraphic trap. The Warukin Field located at the middle of Piraiba (downdip position) to the south and Tapian Timur Field to the northeast (updip position), both have produced or discovered hydrocarbon from the Lower Warukin.

Analog play concept and data integration, not only using old and new data but also comprehensive analysis from surrounding fields is successfully applicable at this field. This approach may be used to discover the overlooked potential of the field and interfield potential. From

this research the calculated contingent resource from this field is approximately 22.14 MMSTB. With the difficulty of IOR or EOR in the existing reservoir, going to the deeper zone may be the best answer to revive the potency and increase production from this field. New development concept is proposed to drill the deeper zone while also looking for remaining hydrocarbon in existing reservoirs using grid based drilling strategy.

Introduction

Warukin Field, located at Barito Basin, South Borneo (Figure 1) is one of the prolific oil fields in Indonesia. Developed from late 1965, this field is now considered a mature field. This field produces from the Middle Warukin Formation. The reservoir is a typical fluvio deltaic sandstone. Following the success of P-Area's exploration well (P-01, 2015) located about 19 km from Warukin Field has proved that the Lower Warukin Formation also contains hydrocarbon. Recent geological and geophysical studies using analog models and integration of old and new data from Warukin and its surrounding fields shows there is hidden and untouched potential from a deeper zone in the Lower Warukin Formation with reservoir character analogs to P-Area's multi layered sandstone reservoir. The complex stratigraphy architecture of the Lower Warukin Formation has proven to be good stratigraphic traps. The Warukin Field located at the middle of P-Area (downdip position) to the south and "TT" Field to the northeast (updip position), both have produced or discovered hydrocarbons from the Lower Warukin Formation.

With the difficulty of IOR or EOR in the existing reservoir, going to the deeper zone and finding new resources in the interfield area may be the best answer to revive the potency and increase production from this field. This study aims to discover the overlooked deeper potential of the field and interfield potential.

Method

In this study, the analog play concept, geophysical analysis, and data integration are used to re-evaluate the potency of the field. There are two main prospects evaluated, the first one is the deeper prospect (Lower Warukin Formation) in the existing field and interfield prospect. Analog facies model is created from comprehensive geology and geophysics analysis to know the delineation of the prolific Lower Warukin Formation reservoir. New structure map has been generated from combining all available data in the Warukin, "D", and P-Area fields including the latest 2D seismic data (acquired 2015). The latest addition of geophysical data is passive seismic measurement that was acquired in 2017. This passive seismic measured low frequency anomaly that can be an indicator of hydrocarbon (Holzner et al., 2005; Saenger et al., 2007; Saenger et al., 2009; and Ramadhan et al., 2013). All the analysis results are then combined to create hydrocarbon prospects maps based on analog play concept and geophysical analysis.

Analog Facies Model and Well Data Analysis

From 49 wells that have been drilled in Warukin Field, there are only two wells that penetrated the Warukin Lower Formation (Figure 2). From those wells, there is good indication of hydrocarbon occurrence even though the reservoir has not yet produced due to mechanical problems. This is the first lead to a deep prospect in the Warukin Field.

The hydrocarbon discovery (DST Test A Zone 294 bopd, 0% WC, DST Test B Zone 147 bopd 0% WC) in P-Area's exploration well (downdip position from Warukin) confirms the hydrocarbon prospect of the Lower Warukin Formation in Warukin Field. Well correlation from P-Area to Warukin shows that P-Area's prospect zone correlates with the Lower Warukin Formation in "D" and Warukin fields (Figure 3). Structurally, the prospect zone in the Warukin lies in the updip position from P-Area (Figure 3). P-Area's reservoirs characters are analogues to Warukin as showed by typical logs of the Lower Warukin Formation which has typical lower delta plain deposit characters (Figure 4a). This fact also confirmed by seismic analysis in P-Area (Figure 4b) which shows that the reservoirs are unconnected and can be good stratigraphic traps. These facts show that P-Area stratigraphic model can be used as an analog to develop the Lower Warukin Formation prospect in the Warukin area (Figure 5).

Interfield Potential

Integrating data of existing fields gives opportunity to re-evaluate the interfield area. New structure map has been generated. Passive seismic acquisition, gives the information of low frequency anomaly which indicated the hydrocarbon occurrence. From passive seismic attributes V/H, known in the interfield area of Warukin, "D" Field has good low frequency with V/H values > 1. Low frequency anomalies are also found in the western area of "D" Field. The distribution of low frequency anomaly can be seen on the Passive Seismic Attribute V/H map (Figure 6). From seismic interpretation, there is onlapping features in the eastern flank of "D" with bright spot amplitude anomaly. In the western area of "D" Field there are four-way dip anticlines that can be potential structural – stratigraphic traps (Figure 6). This prospect most likely corresponds with low frequency anomaly from passive seismic.

Prospect Resume

The source rock from Warukin Formation (Figure 7) shows that Warukin Field has good maturity and has high possibility the hydrocarbons migrated vertically intra formation. There is also lateral migration from Bangkau Deep, that acts as kitchen for Barito Basin, in updip movement north-northwest from basin center (Rotinsulu et al, 1993). From combining all analysis results, the prospect map of Warukin and its surrounding area, two main prospects have been found: (1) existing field deep zone prospect and (2) interfield prospect (Figure 7) with both stratigraphic or structural-stratigraphic play types.

Conclusion

To find new prospects, comprehensive geology and geophysics analysis must be applied in existing and surrounding fields to see the big picture of a field. Data integration can be a major factor ensuring success of the process. Additional information from nearby fields is very important to unlock interfield and deep zone prospects. From this research, there are two prospects area that have been found: (1) existing field deep zone prospect and (2) interfield prospect. Analog facies play concept successfully proved deep zone potential while passive seismic successfully recognized interfield prospects. This result leads to new development scenario to improve oil production.

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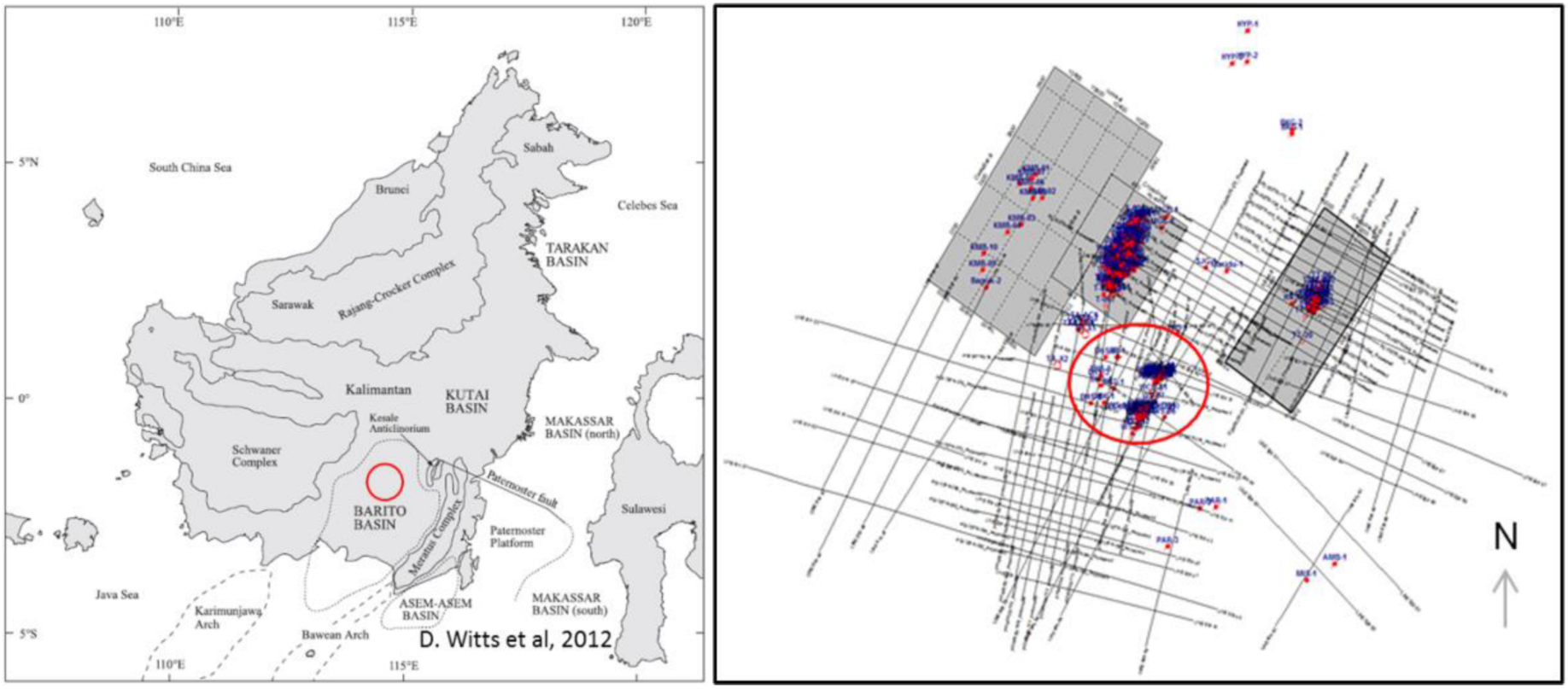

Figure 1. Study area located at Barito Basin, South Borneo, Indonesia (left). Data availability (right)

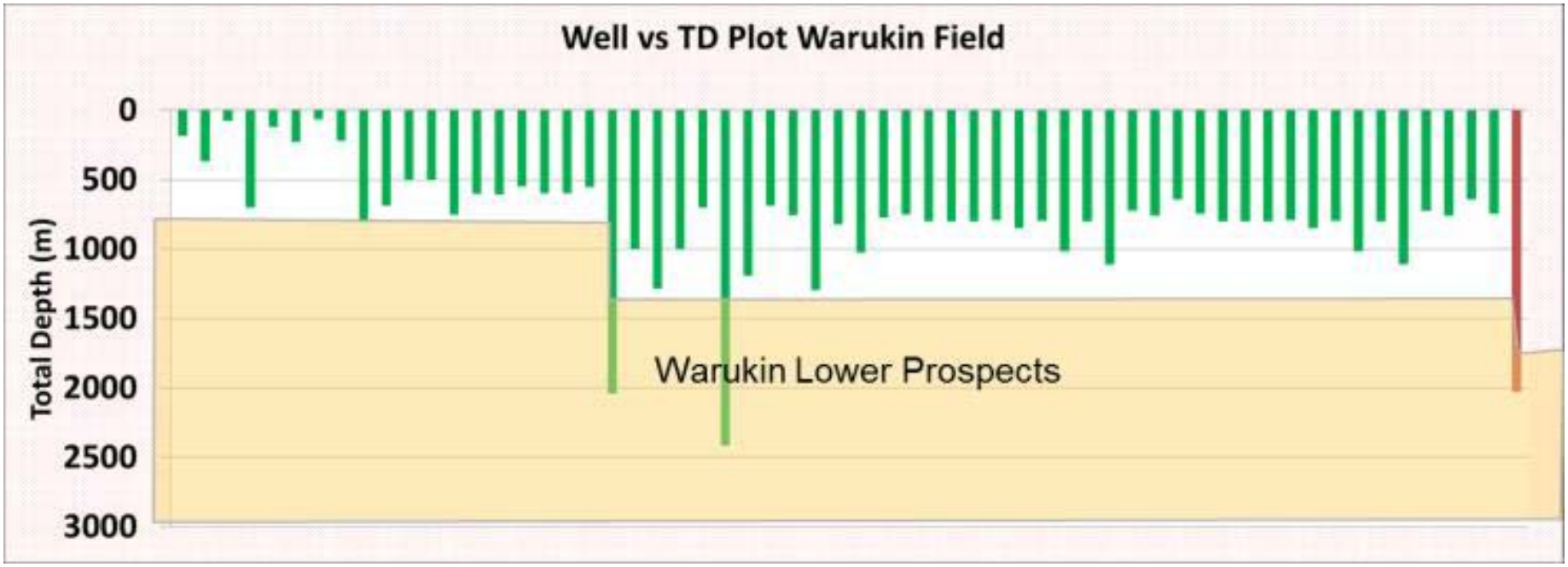

Figure 2. Well vs TD Warukin Field. Comparison total depth drilled in Warukin Field (green) and P-Area Exploration Well (red).

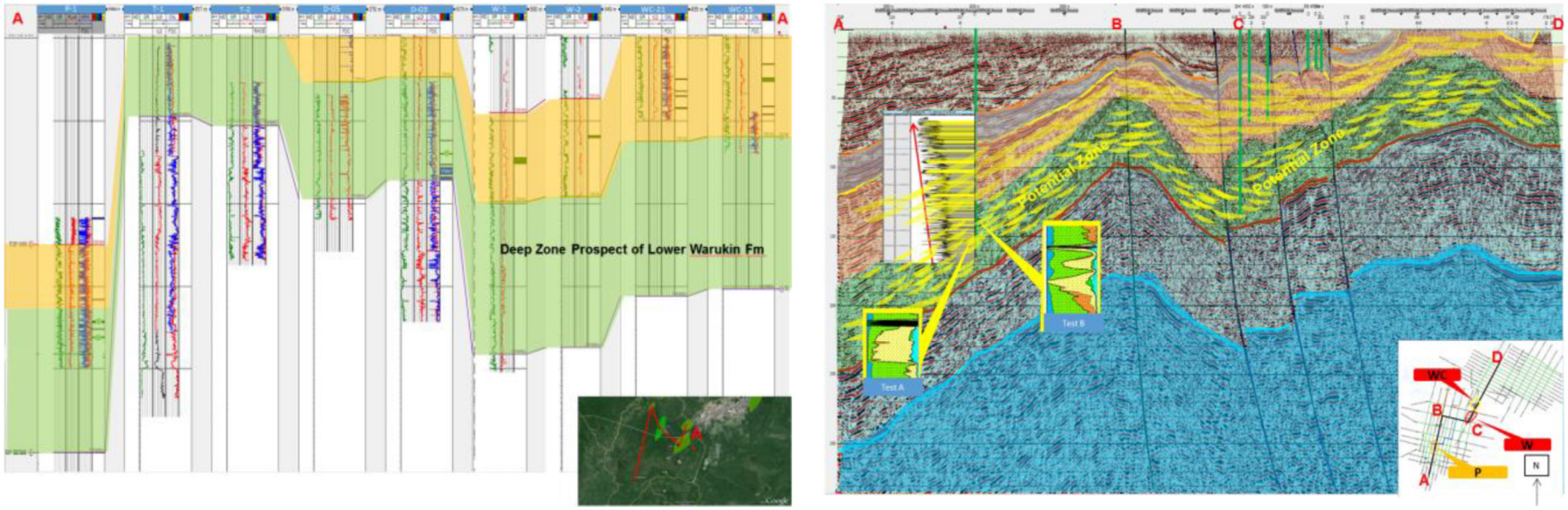

Figure 3. Regional structural well correlation(Left) and Regional Seismic Section (Right) of P-Area, “D” Field and Warukin Field showing new discovery in P-Area lies in downdip position with stratigraphic traps mechanism.

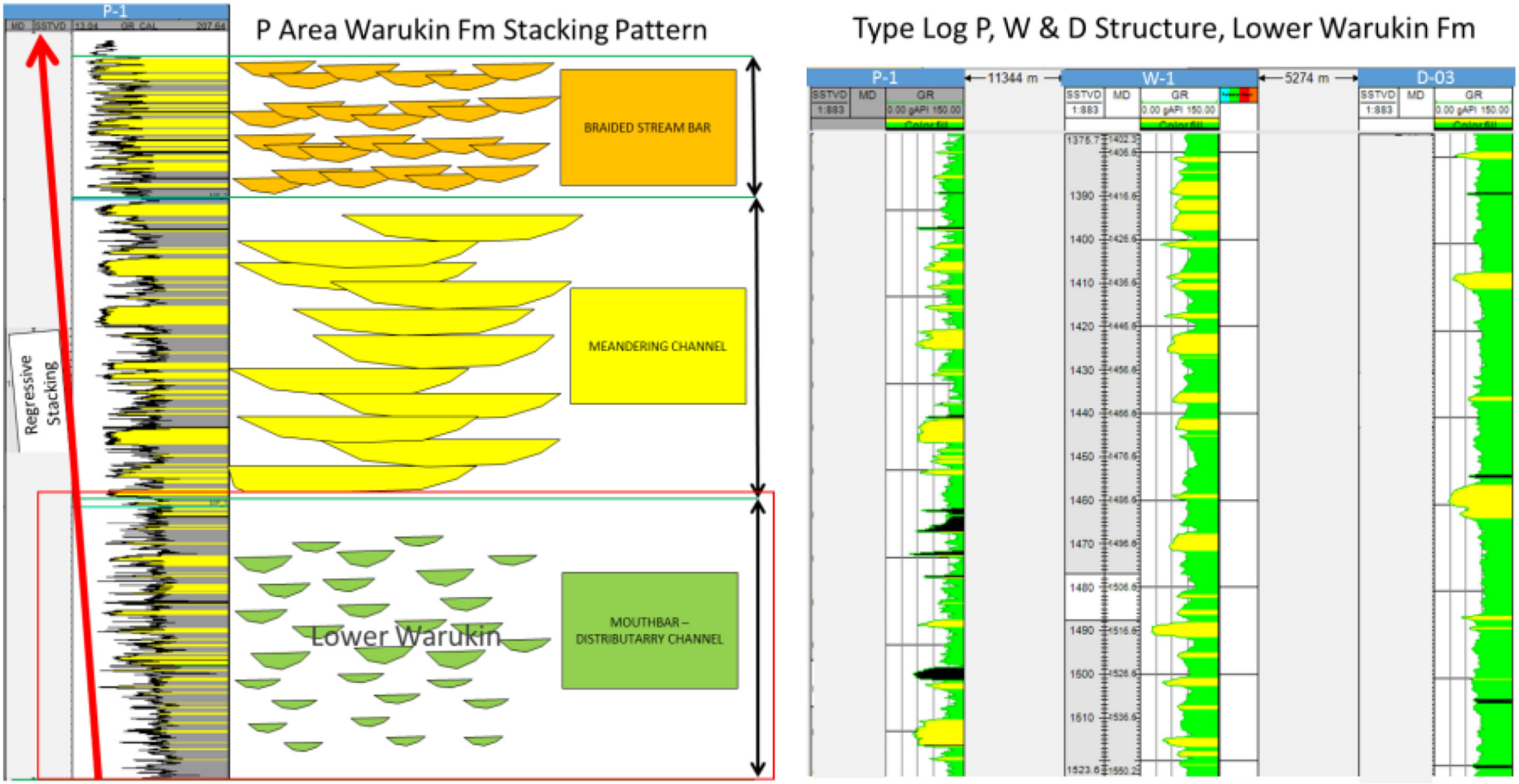

Figure 4a. P-Area Stacking Pattern (left) and Type Log of Lower Warukin Formation reservoir in P-Area, Warukin and "D" Field (right) showing the reservoir share same depositional environment system and reservoir characteristic.

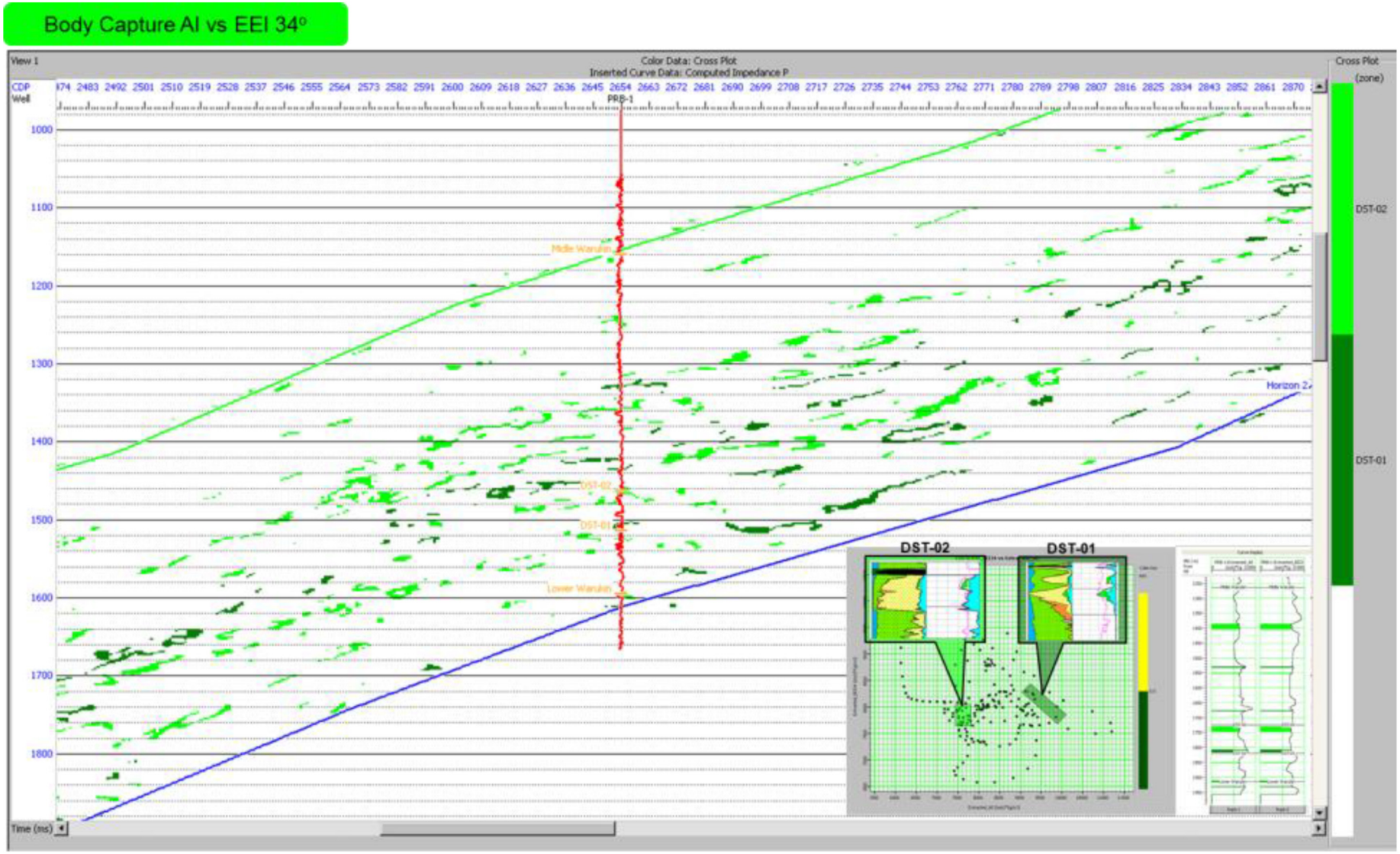

Figure 4b. Seismic Analysis in P-Area showing reservoir pay zone. The reservoir has lenses and unconnected geometry

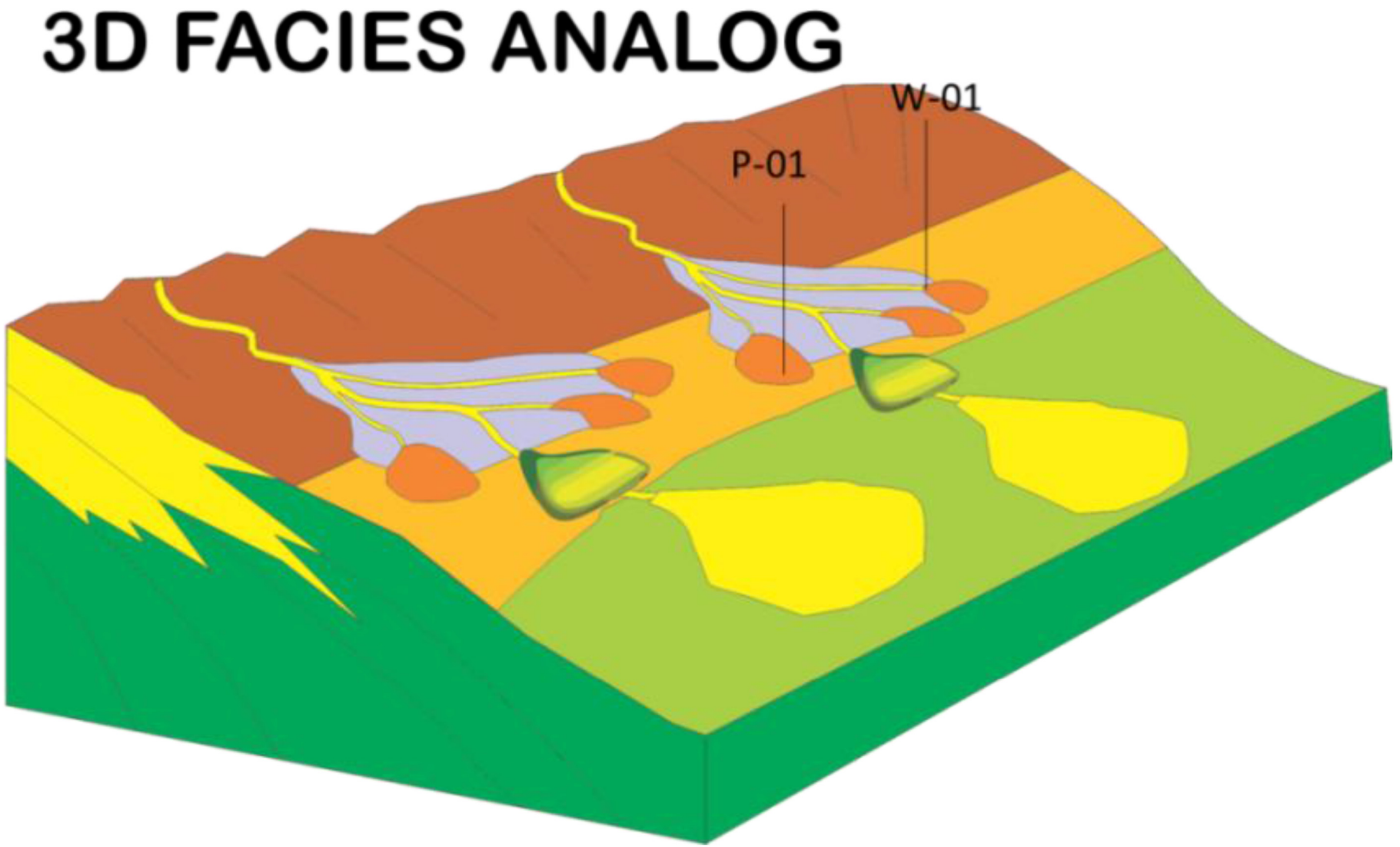

Figure 5. 3D Facies analog of Lower Warukin Formation, generated from comprehensive geological and geophysical analysis showing typical deltaic environment.

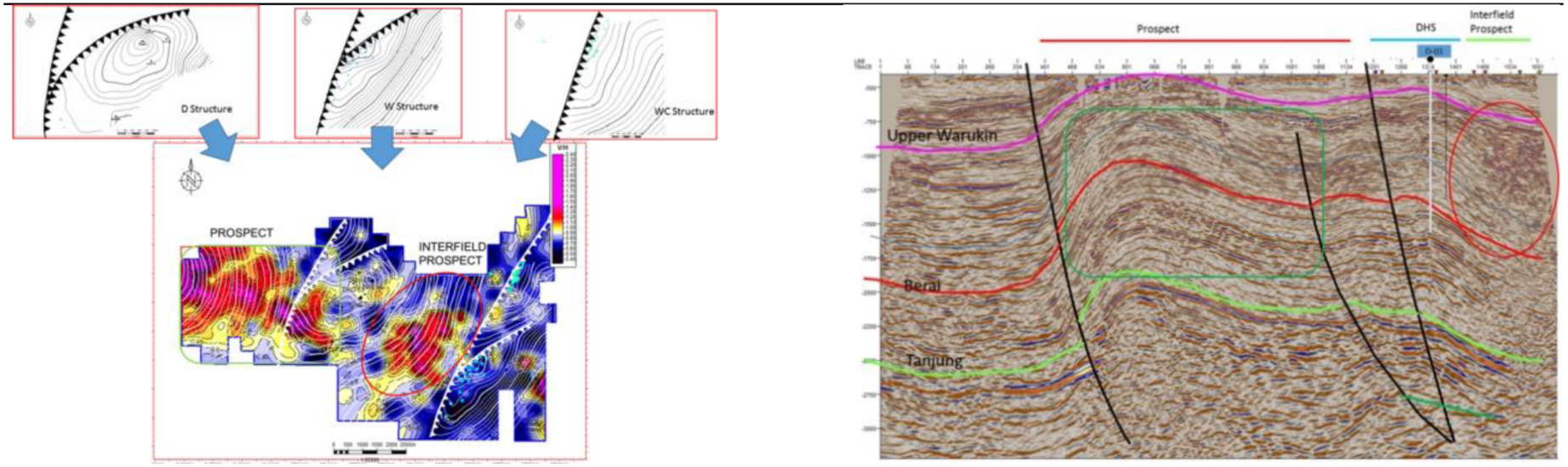

Figure 6. Passive Seismic Attribute V/H Map (left) good low frequency anomaly showed by yellow to red values. Seismic Section over interfield of Warukin – "D" field (right) showed strong hydrocarbon indicator in the eastern flank of "D" Field correlates with passive seismic result.

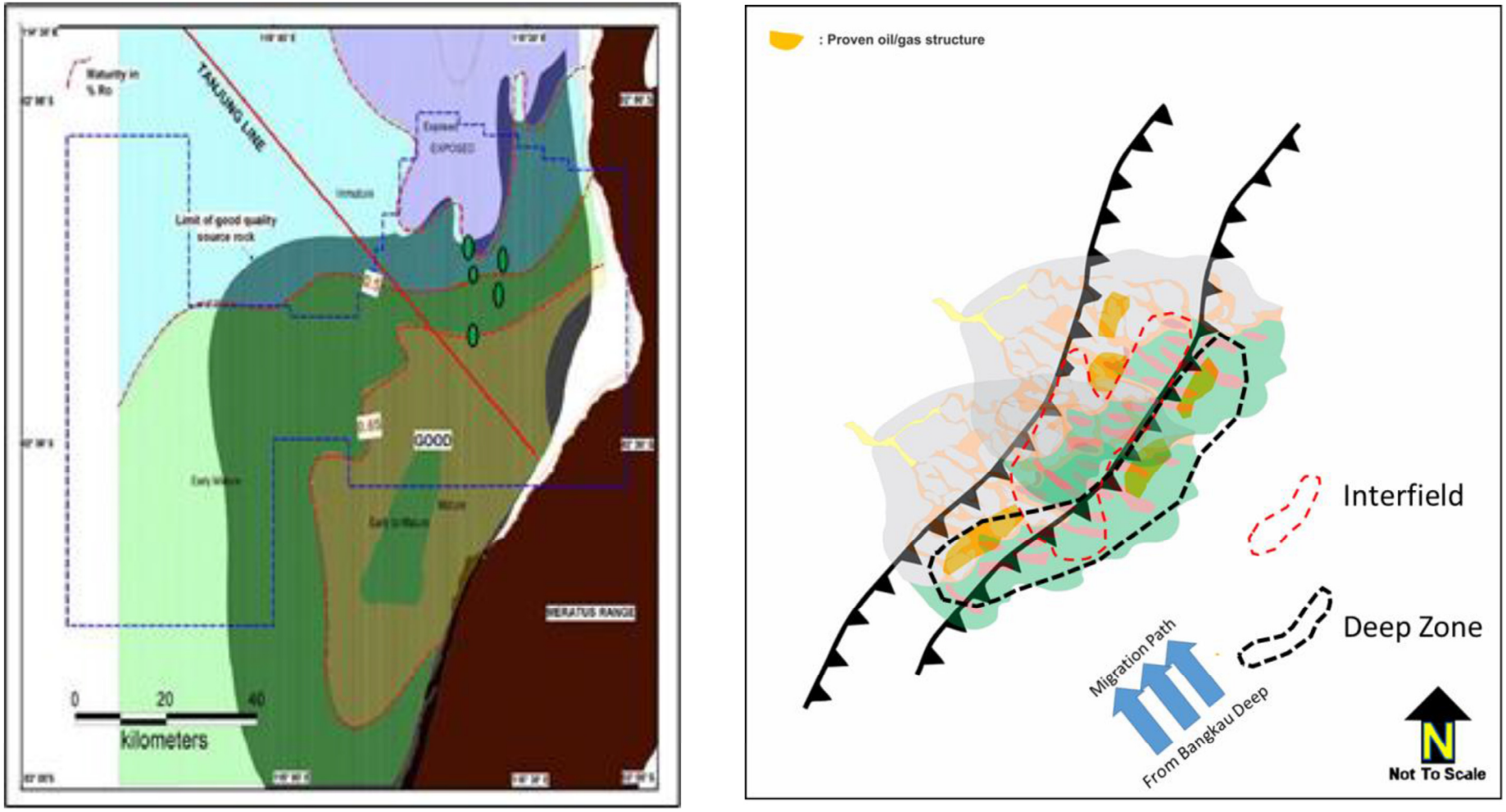

Figure 7. Source rock map of Warukin Formation (left) and New prospect area map of Warukin Field (right). Deep zone and interfield area are the new prospects.