PS The Application of Poisson Impedance Inversion for Sandstone Reservoir Characterization in the Lower Talang Akar Formation, Case Study Melandong-West Java*

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Abstract

The Melandong area is located in the Tertiary North West Java Basin and has proven to be an excellent hydrocarbon field in Java. The Talang Akar Formation (TAF) is characterized as synrift to late rift continental style deposition. The lower part of the formation consists of lenticular, bar and channel-type sand bodies; they are medium grained and poorly sorted, with porosities ranging from 10 to 20%. The sand layer has proven to be new deep gas and condensates reservoir in the Melandong area due to the success hydrocarbon (HC) discovered at well JK-1 and KL-1.

In the Lower TAF, the sandstone reservoirs cannot be clearly separated form shale by using Acoustic Impedance (AI) and Lambda-Mu-Rho (LMR) so that Poisson Impedance (PI) is applied as an alternative solution for reservoir characterization. Quakenbush, et.al (2006) proposed an idea to "extract" the PI value by performing the rotation to the crossplot of Acoustic Impedance (AI) vs. Shear Impedance (SI). Mathematically, this relation is called Poisson impedance and can be shown as PI =AI – cSI, where "c" is rotation parameter of impedances data or inverse of crossplot trending lithology and fluid (Humpson Russell). PI has a very close relationship with the "Fluid Factor" attribute where the simple idea of it is that points that lie further away from the brine-wet trend are more likely to have hydrocarbons.

The PI gives a better result of the sandstone reservoir from the non-reservoirs separation. The lower Poisson impedance is in line with the presence of sandstone reservoir and HC bearing in the well, the sweet spot. In addition, the change of PI with saturation is estimated from Fluid Replacement Modeling (FRM). Combining with the petrophysical data and well test result, the FRM draw the line of optimum value of separation.

3D seismic inversion and visualization provides good distribution and interpretation for the sweet spot. Tectonic setting and biostratigraphy data confirms the depositional environment of sandstone reservoirs. Several new prospects can be identified and convinced by deriving of its geological model.

In conclusion, PI is a very favorable tool for sweet spot identification in the Melandong Area and with integrating geological, petrophysical, and well test data, the sandstone reservoir in the Lower TAF can be characterized properly.

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INTRODUCTION

The most critical objective in the exploration phases is to characterize the reservoir. This is required to generate a drillable prospect, add a development well, a work-over, and enhance field reserves calculation. The Poisson Impedance (PI) Inversion technique have been applied to predict the sandstone reservoir distribution, quality, and fluid content potential in the Lower Talang Akar Formation (TAF). The objective of this poster is to share the application of the PI inversion for sandstone reservoir characterization in the Lower TAF, Melandong Area, North West Java Basin.

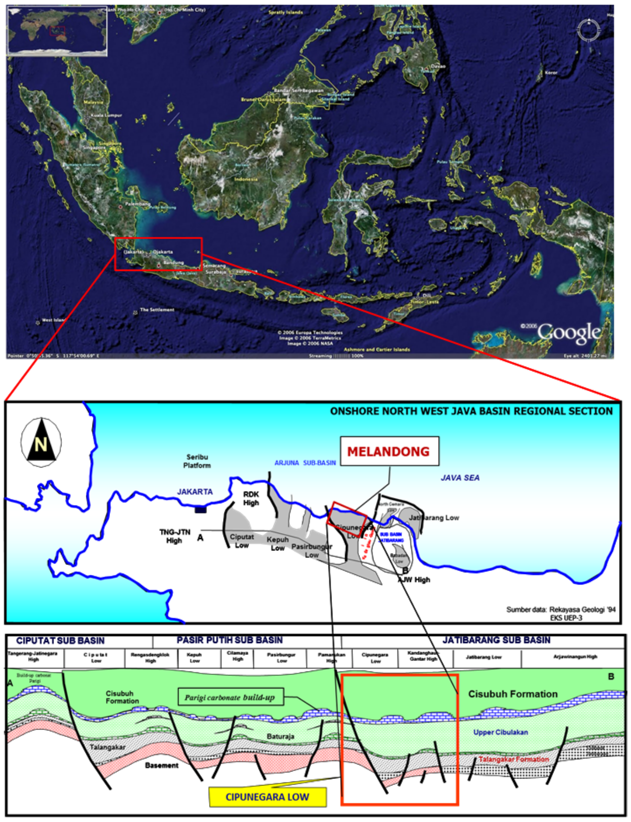


Figure 1. Onshore North West Java Basin Regional Section

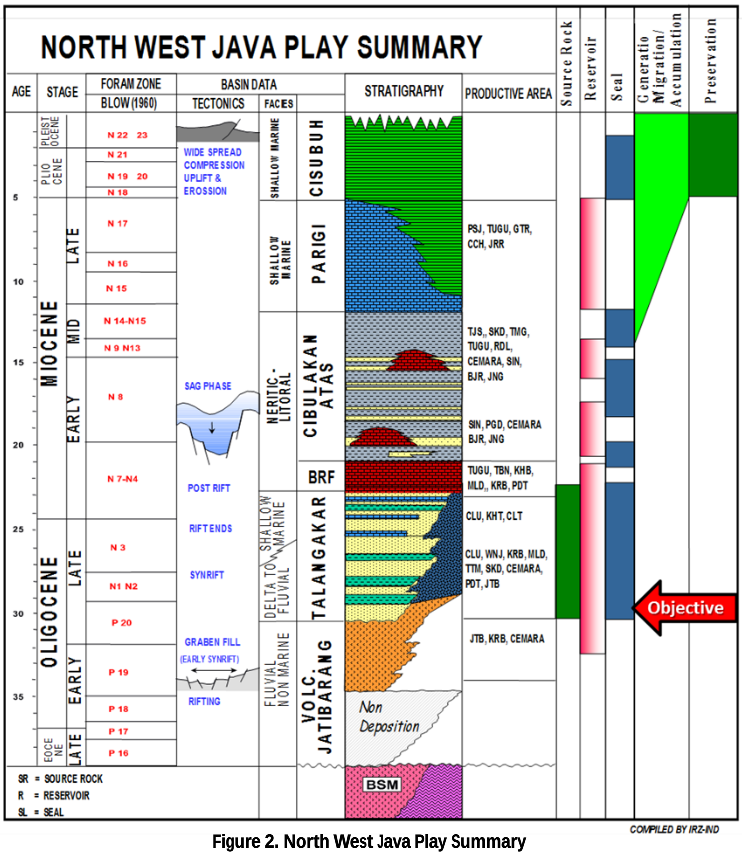


Figure 2. North West Java Play Summary

Melandong area is located in the Tertiary North West Java Basin and has proven to be an excellent hydrocarbon field in Java, Indonesia (see Figure 1). It is part of a series of half-graben basin deposition which has the characteristics of rift basin sediment systems. Patterns that make up half graben faults are generated by the opening of a dextral shear faults (trans-tensional). This normal faults clearly looked in association with centers of deposition of syn-rift sediment. The North West Java play summary are showed in Figure 2 while the basin formation and infilling model in Melandong Area are illustrated in Figure 3.

The Late Oligocene TAF overlies the Jatibarang Formation (JTB) and Basement rocks (see Figure 2 & 3). The formation is characterized as syn-rift to late rift continental style deposition thus interpreted that Oligocene fault controls the sedimentation. The Lower TAF represents continental deposition and the upper part represents an increasing marine transgression. They are consist of lenticular, bar and channel-type sand bodies; medium grained and poorly sorted, with porosities ranging from 10 to 20%. The sand layer has proven to be new deep gas and condensates reservoir in Melandong area due to the success hydrocarbon (HC) discovered at well JK-1 and KL-1.

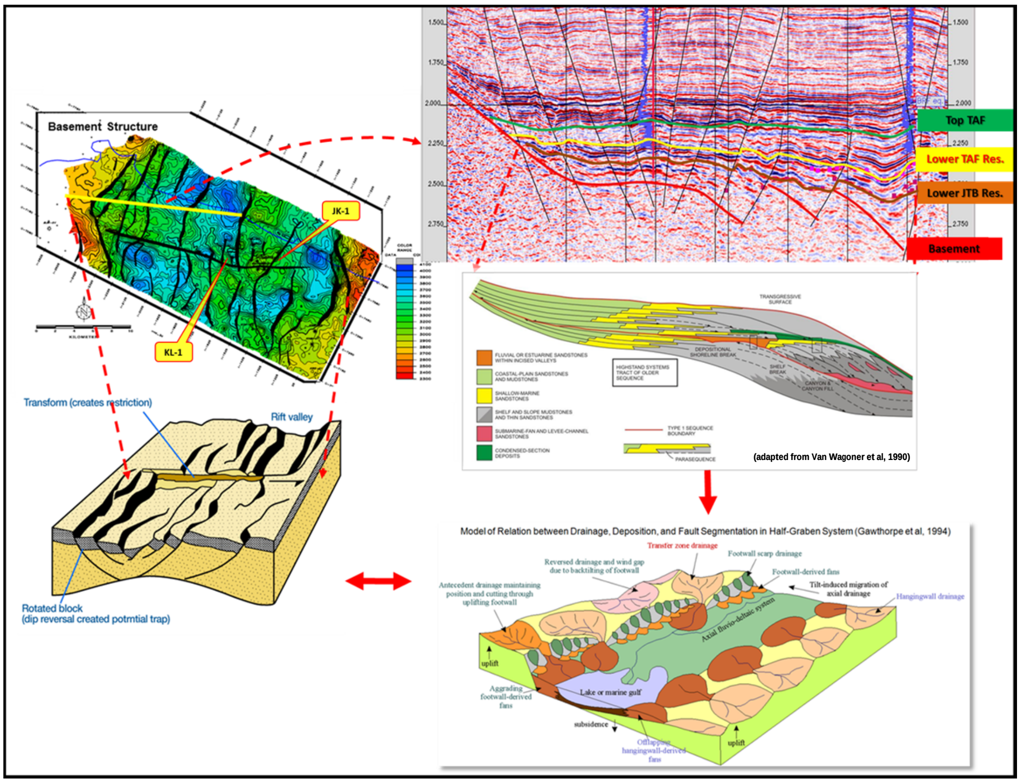


Figure 3. Basin formation and infilling model in Melandong Area

POISSON IMPEDANCE THEORY

Poisson Impedance (PI) was described in a paper called "Poisson Impedance" by Quakenbush, Shang and Tuttle in The Leading Edge, February 2006. Quakenbush, et.al (2006) proposed an idea to "extract" the PI value by performing the rotation to the cross plot of Acoustic Impedance (AI) vs. Shear Impedance (SI). Mathematically, this relation is called Poisson impedance and can be shown as PI =AI – cSI, where "c" is rotation parameter of impedances data or inverse of cross plot trending lithology and fluid. The idea of PI is illustrated in the Figure 4.

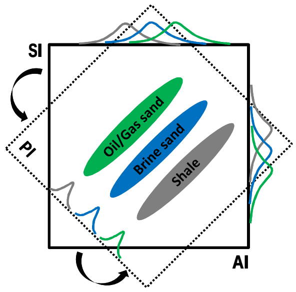


Figure 4. Illustration of Poisson Impedance (*modified from Quakenbush et al., 2006*)

SENSITIVITY LOGS ANALYSIS

In the Lower TAF, the sandstone reservoirs cannot be clearly separated form shale by using P-wave (Vp), S-wave (Vs), Acoustic Impedance (AI), and Shear Impedance (SI). Gas sand and shale almost have similar value of them. However, gas sand and shale plot at somewhat have different linear trends (see Figure 5.).

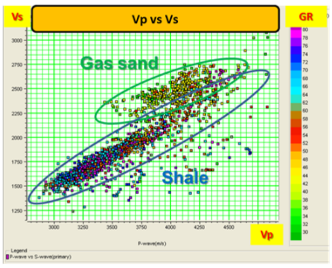
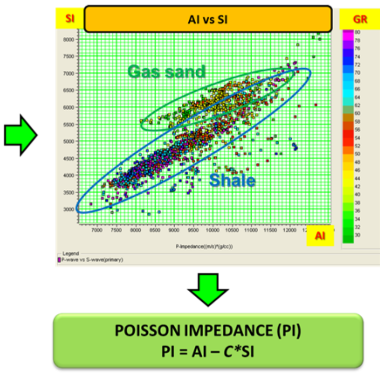
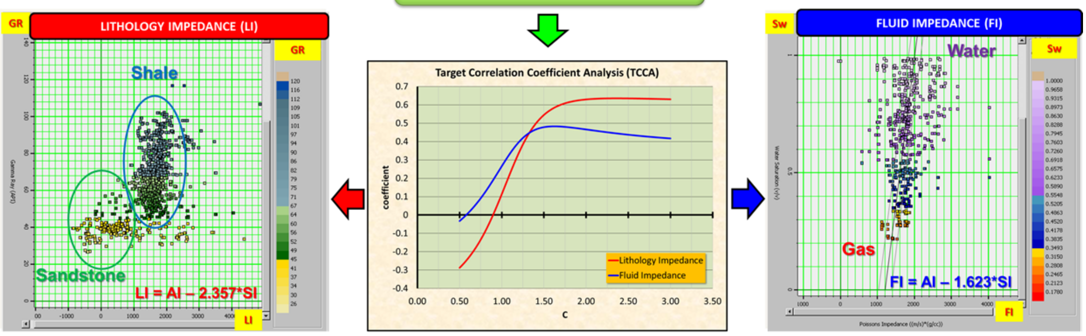


Figure 5. Sensitivity logs and Target Correlation Coefficient Analysis (TCCA)



PI is defined by simple equation as PI =AI – cSI. The "c" term derived from the regression line of the cross-plot of the AI and SI logs for the wet trend. The inverse of the slope could be used as the c value.

In this study, we use Target Correlation Coefficient Analysis (TCCA) method introduce by Tian, et. al. (2010) to calculate "c". We calculate automatically the correlation coefficients between PI curve with different C-values versus Gamma Ray (GR) curve and Water Saturation (Sw) curve. The maximum correlation coefficient is reached in C-value is 2.357 for GR (cc = 0.6378) and 1.623 for Sw (cc = 0.4831). Hence, we can derive two attribute of Poisson Impedance : Lithology Impedance (LI) using equation LI = AI – 2.357*SI, and Fluid Impedance (FI) using equation FI = AI – 1.623*SI. They are used specifically with its sensitivity to lithology or fluid effect.



Cross-plots LI versus GR show the advantage of LI in distinguishing sandstone from shale. They have different cluster. The LI ~1000 m/s*gr/cc indicate the cutoff of its separation. Cross-plots FI versus Sw shows that we can predict the fluid content from its "linier relationship". The low FI correlable with low water saturation and vice versa. several points that deviate from the cluster interpreted as a lack of good data acquisition

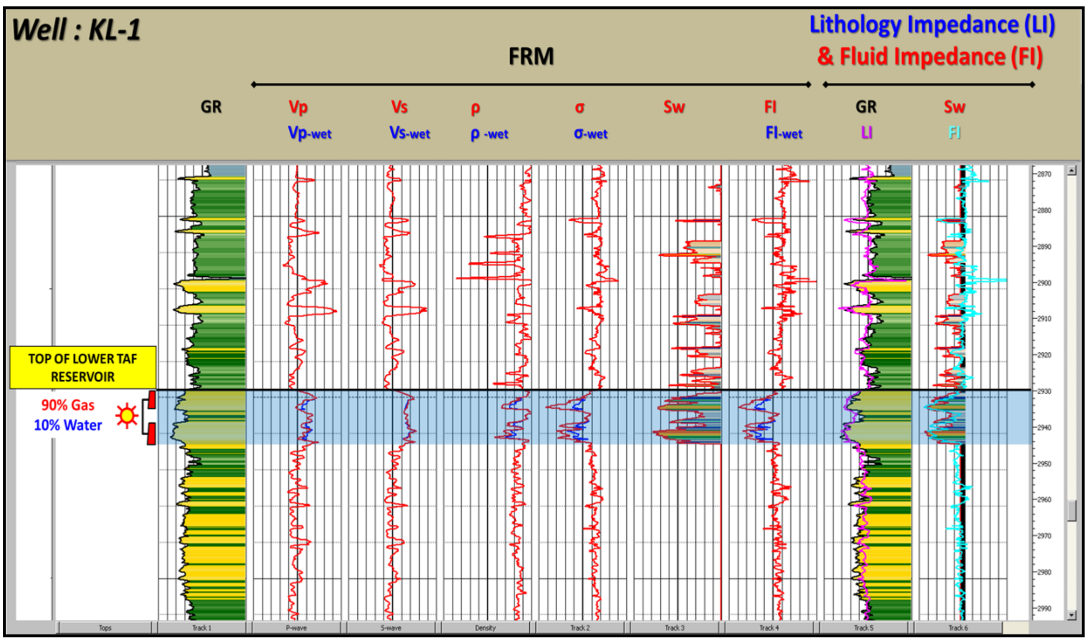


Figure 6. Fluid Replacement Modeling (PI) and Poisson Impedance (PI) attributes Comparisons at KL-1 well.

FLUID REPLACEMENT MODELING (FRM)

The FRM allows us to see what logs would look like with different quantities or type of saturation, especially compressional sonic (Vp), shear sonic (Vs), and Density (ρ). Within the FRM, the Biot-Gassman equations is used to convert the actual P-wave log within the reservoir in KL-1 from the in-situ fluid, 90% Gas and 10% Water, to fully water saturated (wet). Then, PI-wet is calculated by using log Vp-wet, Vs-wet, and ρ-wet from FRM (see Figure 6).

It is showed that PI decrease with increasing Sw but the it does not make the value equal to PI for shale. This phenomenon gives clue that we have to separate the effects of fluid and lithology for unambiguously. Therefore, the FI and LI is then used based on our purpose of determining the distribution of sandstones reservoir and predict its fluid content.

Generally, LI log (violet curve) have similar trend quite well with GR log (black curve) as well as FI log (cyan curve) to Sw log (red curve). Qualitatively, the presence of Lower TAF sandstone reservoir can be represented by low LI and FI values. In practical terms, for quantitative interpretation, the LI and FI values can be converted into a normalized value of GR (volume of shale) and Sw (fluid content potential) and called as scaled LI and scaled FI.

POISSON IMPEDANCE VOLUME

The work flow for Poisson Impedance (PI) involves calculating RP and RS seismic volumes from pre-stack data. Two inversions are performed to create AI and SI volumes and then derive LI and FI. Practically, PI incorporates both Poisson Ratio (σ) information and Density (ρ) into a single display attribute which has been useful in reservoir delineation. In addition, because ρ is not being determined separately, but in combination with the σ information, such a combined attribute does not have a far-offset data requirement for stability, just as the combined *Vp* and ρ attribute of AI does not require far-offset data beyond 30° (Quakenbush, et.al., 2006).

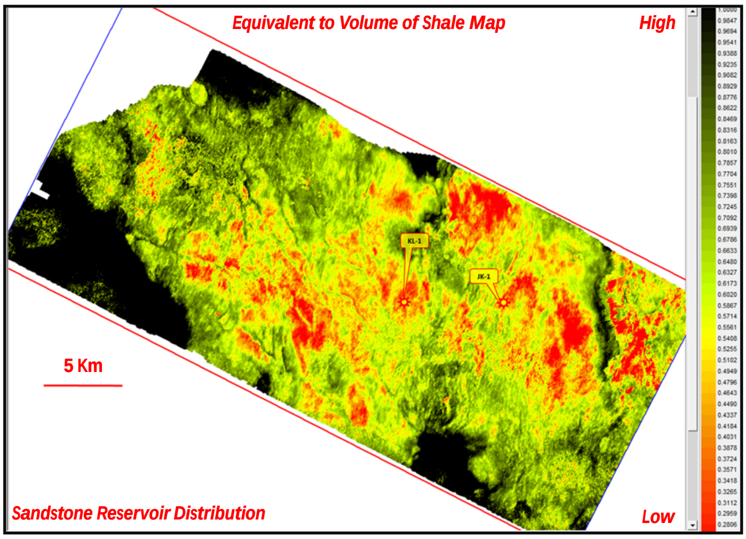


Figure 7. Scaled Lithology Impedance (LI) Map Of Lower TAF Reservoir

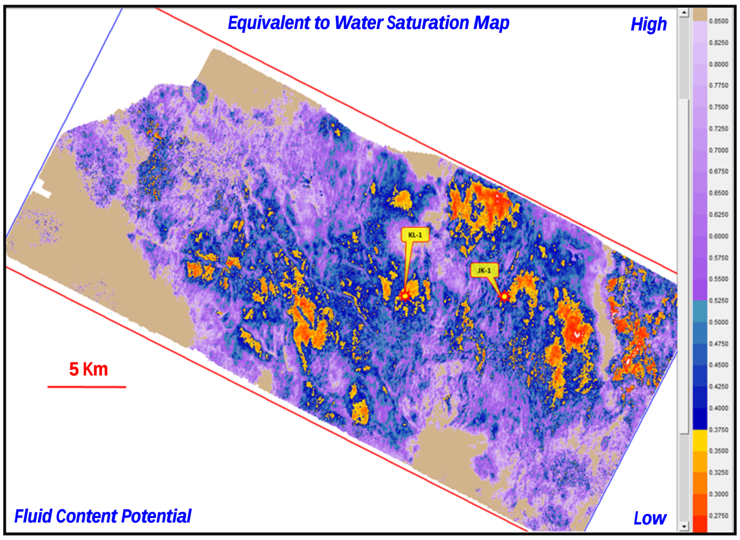


Figure 8. Scaled Fluid Impedance (FI) Map Of Lower TAF Reservoir

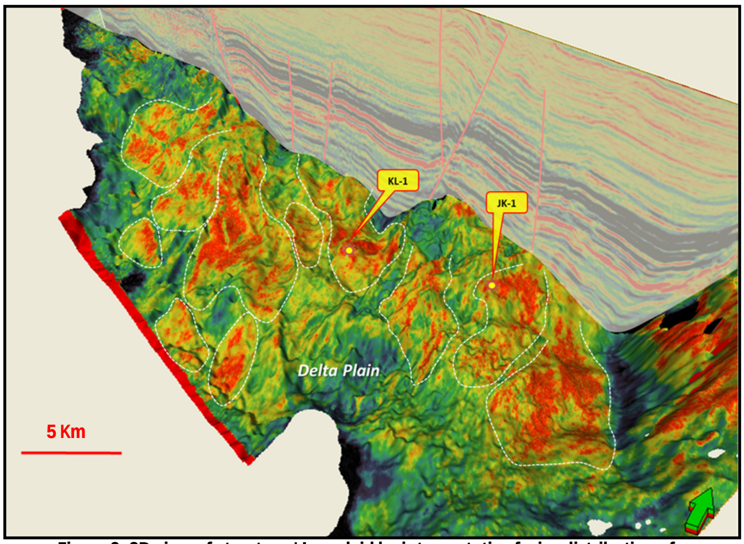


Figure 9. 3D view of structure-LI overlaid by interpretative facies distribution of Lower TAF

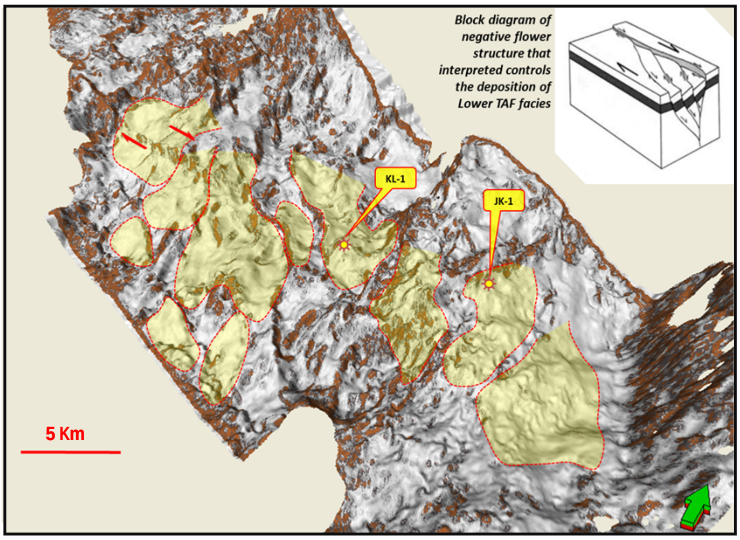


Figure 10. 3D view of structure-variance overlaid by interpretative facies distribution of Lower TAF that controlled by faults.

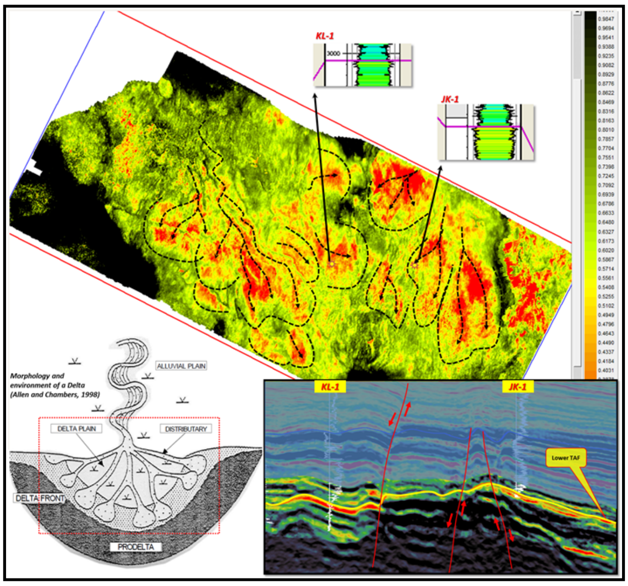


Figure 11. Geological model of Lower TAF facies distribution

Figure 7 to 11 show the result of PI inversion. 3D seismic inversion and visualization provides good interpretation for our reservoir. It is interpreted as a part of Deltaic System, Delta Plain. Its distribution are highly controlled by fault occurred in Late Oligocene syn-rift within NW-SE and N-S as main direction of deposition. The tectonic setting and biostratigraphy data confirms the depositional paleo-environment of the Lower TAF. By complete interpretation and deriving geological model, it is showed that several new prospects can be identified and convinced in the west part of KL-1 and in the east part of JK-1.

CONCLUSION

In conclusion, PI is very favorable tools for Lower TAF sandstone reservoir characterization in Melandong Area. Using TCCA method, we can derive two attribute of PI there are Lithology Impedance (LI) and Fluid Impedance (FI). The results of log curve show that sandstone and shale can be well distinguished by LI. The distribution of sandstone described by LI is well consistent with the structure and deposition background in this area. While, FI provide an potential fluid content identification. Integrating with geological, petrophysical, and well test data, the sandstone reservoir in the Lower TAF can be characterized properly and new prospect can be identified directly.

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REFERENCES CITED

Allen, G.P. and Chambers, J.L.C. 1998.Sedimentation in the Modern and Miocene Mahakam Delta. Indonesian Petroleum Association, Jakarta, 236pp.

Gawthorpe, R.L., Fraser, A.J., Collier, R.E. & LL., 1994, Sequence stratigraphy in active extensional basins: Implications for the interpretation of ancient basin fills. Mar. Petrol. Geol., 11, 642–658.

Quakenbush, M., B. Shang, and C. Tuttle , 2006, Poisson impedance: The Leading Edge , 25, no. 2, 128–138.

Tian, et. al., 2010, Reservoir prediction using Poisson Impedance in Quinhuangdao, Bohai Sea : SEG Denver 2010 Annual Meeting, 2261-2264.

Van Wagoner, J.C., R.M. Mitchum, K.M. Campion, and V.D. Rahmanian, 1990, Siliciclastic sequence stratigraphy in well logs, cores, and outcrops: Tulsa, Oklahoma, American Association of Petroleum Geologists Methods in Exploration Series, No. 7, 55 p.

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