PROCEEDINGS
JOINT CONVENTION BANDUNG (JCB) 2021
November 23rd – 25th 2021

RESERVOIR CHARACTER IDENTIFICATION USING EXTENDED ELASTIC IMPEDANCE INVERSION IN "MR" FIELD, NATUNA BASIN

Muhammad Riyo Hanafi[1], Ignatius Sonny Winardhi[1].
[1]Geophysical Engineering, Faculty of Mining and Petroleum, Institut Teknologi Bandung

Abstract

Reservoir character identification is one of the key process in petroleum exploration. One of the petroleum exploration target is one of sedimentary formation in Natuna Basin, Udang Formation. Udang Formation at "MR" Field in Natuna Basin considered as a potential hydrocarbon reservoir. Through regional geology point of view, it consists of interbedded sandstone-shale with braided delta and lacustrine plain as depositional environment, which is a supporting proof of its potential as a reservoir. One of the method to analyze reservoir characteristic is through seismic inversion that modelled subsurface condition. Extended elastic impedance (EEI) inversion is one of inversion type that modify elastic impedance's angle projection, so it could add more possibility of parameter covered in reservoir characterization. Inversion process use sensitive parameters that consist of mu-rho (rigidity) and lambda-rho (incompressibility). These two parameters used to show developed lithology characteristic at "MR Field" linked to hydrocarbon existence. Mu-rho with EEI (84°) and lambda-rho with EEI (336°) shows clear reservoir characteristic along the formation's bed and the formation below and under it. Hence based on the result of EEI inversion, Udang Formation in "MR" Field has a good lateral spreading of high rigidity and low incompressibility that related to the presence of sandstone and possible to be taken as a sign of hydrocarbon presence.

Keywords: Extended Elastic Impedance, Natuna basin, Reservoir Characterization.

Introduction

Petroleum exploration has a close relationship with basin's petroleum system or the field itself to be specific. The petroleum system itself really determined petroleum content whether it is an oil or gas. This act as a basic knowledge needed to consider field's economic value. One of the part on petroleum system is reservoir. Identification of reservoir is an important step in exploration as it related to the petroleum accumulation.

"MR" field is one of the field located in Natuna Basin or West Natuna Basin to be more specific. Natuna Basin already well known with Gabus Formation and Udang Formation as petroleum reservoir (Pangarso, 2010). It related to the lithological content of both the formation itself, which is sedimentary rock consist of interbedded sandstone and shale (Darman & Sidi, 2000). Schon (2015) mentioned that sedimentary rock is an important type of rock in hydrocarbon exploration activity. Hence, as Udang Formation is one of the formation in MR Field, it is intriguing to know the quality and potential. Through this research, reservoir characteristic from MR Field will identified well and there is a possibility for further interpretation through the help of seismic inversion.

Extended elastic impedance (EEI) inversion is an improvement of elastic impedance (EI) inversion. The goal for the inversion is to enhance in fluid separation. EEI developed EI inversion with adding more angle (-90° to 90°). This addition add the inversion's flexibility in contact with seismic parameters. This research aim to show that EEI can be effective to unveiled the reservoir characteristic in "MR" Field especially Udang Formation and furthermore can give an option in processing the seismic inversion. In this research, acoustic impedance – shear impedance (AI-SI) projection used to see the sensitivity of seismic parameter. It is based on Connolly (1999) in Whicombe et al. (2002). This projection applied on AVO analysis will be:

$$EEI(\chi) = AI^{\cos(\chi)} SI^{\sin(\chi)} \quad (1)$$

$$R(\chi) = R_p \cos(\chi) + R_s \sin(\chi) \quad (2)$$

Data and Method

MR-01 well in MR Field is the only well used in this research. The well data consist of density, gamma ray, neutron-porosity, p-wave, s-wave, check shot logs, and tops from each formation. Other than logs, the field also has pre-stack 3D seismic data with angle stack near 6°-16°, mid 17°-27°, and far 27°-36. All of this data used in the processing step.

Before proceeding into seismic inversion process, the process started with sensitivity analysis of seismic attribute cross plot using well log data. The analysis conducted using cross plot of seismic attributes. Attributes used in this research are mu-rho and lambda-rho with the addition of gamma-ray index and density & neutron log as a separating attribute. The result is both of the attributes considered as sensitive parameter showed by its ability in separating between reservoir and non-reservoir (sand and shale lithology).

Other than that, targeted zone condition also considered in the process.

Cross plot showed that lambda-rho (incompressibility) and mu-rho (rigidity) able to differentiate between rocks and higher-lower gamma ray value well. Furthermore, looking from cross plot between lambda-rho and density, targeted zone with the characteristic of low lambda-rho, shows low density and low neutron value. The information relating to sensitivity condition then used as a base for the inversion process to the two parameters.

Tuning thickness, which is a minimum thickness for a layer to be able to be resolved by the seismic, obtained by using equation of wavelength divided by 4. Wavelength calculated using the already known information of average velocity and amplitude. The average of velocity obtained using average of shear wave velocity in the targeted zone. Furthermore, amplitude value obtained by looking at dominant amplitude value from the seismic. Vertical thickness, also called tuning thickness, then calculated using wavelength from average speed of 4956 m/s divide by dominant frequency of 44 Hz. This calculation resulted in more or less tuning thickness 28 m. Compared with sandstone beds thickness on targeted zone (Udang Formation), the thickness is hard to be resolved as it is considered thin layers. However, if all of them grouped as an interbedded sandstone-shale, then it is possible to be resolved as the thickness is more or less 35 m.

Inversion process started with looking at reflectivity from P and S waves. Using calculation with the equation provided by Ursenbach & Stewart (2008) on Thomas (2016), the coefficient value obtained through inversion matrix process from each seismic angle. The result is coefficient showed in the Table 1. Angle data gathered from angle stack are near 11°, mid 22°, and far 31,5°.

Referring to sensitivity processing result, lambda-rho and mu-rho are the focus of inversion step. Correlation angle from each parameter are 336° for lambda-rho and 84° for mu-rho. The value obtained by looping of angle projection range on EEI in order to see which angle suit best to act as correlation angle. Both of the angle then applied into formula (2) to obtained seismic volume from each sensitive parameter.

Well seismic tie on MR-01 well used to get the best suitable connection between the seismic data and well. Seismic volume that correlated with well data are mu-rho and lambda-rho. There are two wavelets used in this process that obtained using well extraction method in full wavelet. After stretching and shifting processes, correlation value obtained are 0,679 for mu-rho and 0,622 for lambda-rho.

Using model based inversion as a method in the inversion, the base model made using lambda-rho and mu-rho seismic volume. Low pass filter used in the process of making the base model. The model then used as a base model after being iterated a few times to obtain the best result. Following base model creation is pre-inversion analysis. It aim to find the best result possible that represented by low error value. Finally, both of the seismic volume (mu-rho and lambda-rho) inversed with EEI in model based method.

Result and Discussion

Based on inversion of each main parameters, mu-rho and lambda-rho, the result of seismic inversion already has a correlation with the well log data (Figure 1). On the target zone, mu-rho value considered as high mu-rho compared to other zone outside of the target. For the parameter that related to fluid, which is lambda-rho, showed relatively low value. Both of this condition can be interpret as hydrocarbon fluid zone. Hydrocarbon show in a sandstone type reservoir shows by higher rigidity is very possible in this type of situation. In order to verify the findings, data slice in the targeted zone used to see in a wider scope.

Data slice conducted in the targeted zone, which is Udang Formation, in each of inversion result. Data used in the slicing process are lambda-rho and mu-rho on the range of target zone (Figure 2). High mu-rho related to sandstone has a lateral expansion throughout southwest – northeast. Lambda-rho shows almost the same pattern with low lambda-rho. This distribution of sandstone and hydrocarbon suspect supported by the time structure map available on the field. Combining the entire information, targeted zone located in the area had a higher elevation and there is a possibility in term of hydrocarbon accumulation through structural trap. This finding shows seismic inversion result that represent reservoir character is correct.

Conclusions

Based on the analysis above, there are several points that can use as a conclusion.

1. From the sensitivity analysis, the most sensitive parameters are mu-rho for lithology and lambda-rho for fluid. This is correlate with well log analysis, where hydrocarbon accumulation found at the targeted zone.
2. From the inversion result, hydrocarbon zone can be found on Udang Formation showed by high mu-rho value (sand) and low lambda-rho (hydrocarbon). From the volume slice showed and confirmed the sandstone beds and hydrocarbon content of target zone mapped around the field. Time structure map shows that the target zone located in a higher elevation compared to the surrounding zone.

3. It is very possible to use the EEI inversion in reservoir characterization especially with more data available that can make the interpretation richer.

References

Burton, D., and Wood, L.J., 2010, AAPG Bulletin, **94(11)**, 1695 – 1712.

Connoly, P., 2010, CSEG Recorder, 7 – 10.

Darman, H. and Sidi, H.F., 2000, Ikatan Ahli Geologi Indonesia.

Doust, H. and Noble, R.A., 2008, Marine and Petroleum Geology, **25**, 103 – 129.

Hendrayana, Y., Pangarso, B., and Asaad, M.A., 2012, IPA 36th Annual Convention & Exhibition Proceedings.

Pangarso, B., Hartadi, E., Sihombing, I., Guttormsen, J., Schmitz, P., Wijayanti, R., and Darmadi, Y., 2010, IPA 34th Annual Convention Proceedings.

Schon, J.H., 2015, Elsevier, 4 – 10.

Thomas, M., Ball, V., Blangy, J. P., and Tenorio, L., 2016, The Leading Edge, **35(5)**, 438 – 444.

Whitcombe, D. N., Connoly, P. A., Reagan, R. L., and Redshaw, T. C., 2002, Geophysics, **67(1)**, 63 – 67.

	Near	Mid	Far
Rp	0,9637	0,3772	-0,3224
Rs	2,6853	0,3915	-2,3908

Table 1: Result of matrix inversion from seismic angles. Value used to calculate reflectivity of p-wave (Rp) and s-wave (Rs).

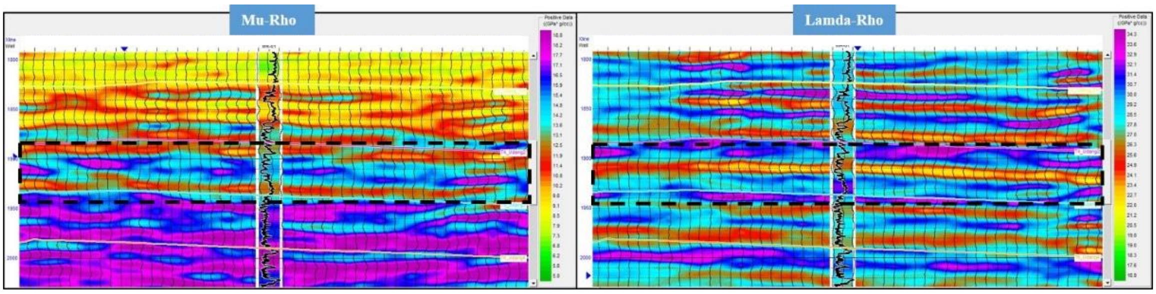

Figure 1: Final inversion result from mu-rho and lambda-rho. Each parameters from the log used in the confirmation of inversion result.

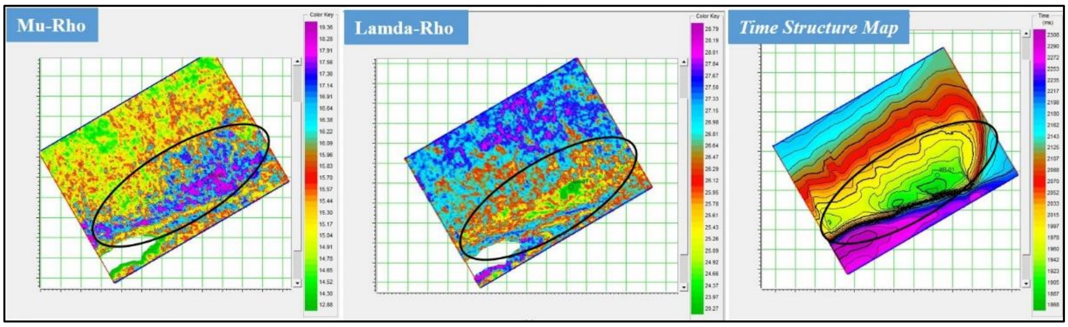

Figure 2: Slices on the targeted zone to verify the anomaly.