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

Porosity Prediction of a Carbonate Reservoir in KF Prospect, North East Java Basin Based on The Integration of Seismic Attribute and Acoustic Impedance Inversion

Khusnul Fitroh[1], Ahmad Khairul Azmi[1], Fitriyanda Herawan[2]
1 Universitas Islam Negeri WalisongoSemarang
2 Pertamina Hulu Energi Tuban East Java

Abstract
Porosity prediction is still an obstacle and a challenge for geologists and geophysics in the carbonate reservoir of KF prospect, although the surrounding field has high hydrocarbon production. Well data, seismic data, there are still not many that can be used as a reference for reservoir characterization due to the lack of exploration wells around the RF prospect. As a consequence, the prediction of porosity is difficult to map, and this results makes it difficult to interpret hydrocarbon traps and determine prospects for new wells.
In order to have a better porosity prediction, data integration of geological data, well log data, the latest seismic data, seismic attribute extraction and utilization of acoustic impedance inversion are used to optimize the geological interpretation. Regional geology data provide the understanding that the structural trap is coming from E-W direction. The structures that develop in the East Java Basin are mostly in the form of anticlines and faults and stratigraphy are found when carbonate unit onlap and cover high sections of bedrock. In addition, the well log data shows the determination of the formation boundary location in the prospect and greatly contributes as an input to the acoustic impedance inversion process. Besides that, extraction of seismic attribute, in this case, it uses the instantaneous phase attribute which shows the continuity of the seismic layer laterally and the continuity of the seismic trace which contributes to the clearer carbonate build-up on the seismic reflector which is then reinforced by regional stratigraphy which shows that there is a carbonate build-up in high areas.
By doing the well seismic tie, it is obtained seismic data at true depth and the role of the instantaneous phase attribute is also very useful in the picking process, because the discontinuity of the seismic traces is seen more clearly so it makes the picking process easier. And to predict porosity, an inversion model is built to produce a map of the distribution of the porous zone in the target area from the interpolated well logs and target horizon.
Based on this analysis, the distribution of high porosity or porous zones is found in the northern and southern areas of the fault. The construction of acoustic impedance inversion models and structural map are interpreted as important factors in determining porous zones, and can be interpreted using integrated geological and geophysical data.

Introduction

KF prospect is located in the North East Java Basin which is one of the oil and gas prospect areas that can be targeted by new exploration wells, with carbonate lithology as a reservoir that located in the Tuban Formation (Figure 1). The Tuban Formation of North East Java Basin has been managed by PT. Pertamina Hulu Energi Tuban East Java.

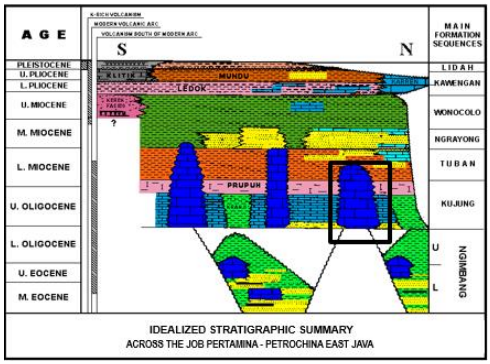

Figure 1: Stratigraphy regional of North East Java Basin (Pertamina – Petro China East Java, 2009)

In developing information regarding the distribution of reservoirs in the stage of determining the location of optimal wells can use seismic attributes and seismic inversions. Both methods are considered suitable for mapping and knowing the subsurface state so that the area of hydrocarbon prospects can be known.

Regional Geology

The North East Java Basin tectonics are in the back arc basin (Figure 2).

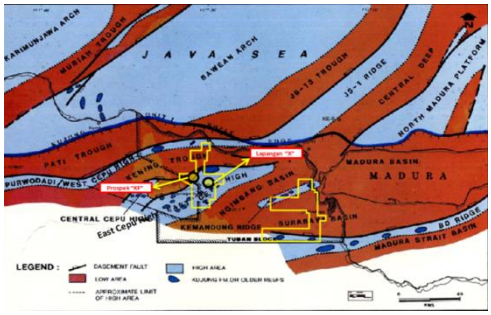

Figure 2: North East Java Basin Tectonics (JOB Pertamina -PetroChina East Java, 2009)

The basin formed in East Java is divided into three mandala structures each from north to south are Paparan Utara, Tinggian Tengah, and South Basin. Paparan Utara is composed by Bawean Arc back arc basin, Sunda Arc System, Northern Platform Central High, Southern Basin Bawean Arc, and Paparan Utara to Madura / North Kangean. Tinggian Tengah consist of Kujung, Madura, Kangean and Lombok Heights, while in the South divided into several Zones namely: Rembang Zone, Randublatung Zone and Kendeng Zone.

Data and Method

The study used methods of seismic attributes and acoustic impedance inversions where the data used are:

- Well data as many as 5 data that have data log neutron porosity, gamma ray, resistivity, density and some have checkshot and top markers.
- 3D post-stack time migration seismic data with depths up to more than 8000ft.

The process of data processing begins with cross plot analysis of log data to find out the character of the reservoir and the location of the reservoir depth. Horizon interpretation is performed on top tuban formations and carbonate formations with markers and log data as references. Below is a flow chart of the study:

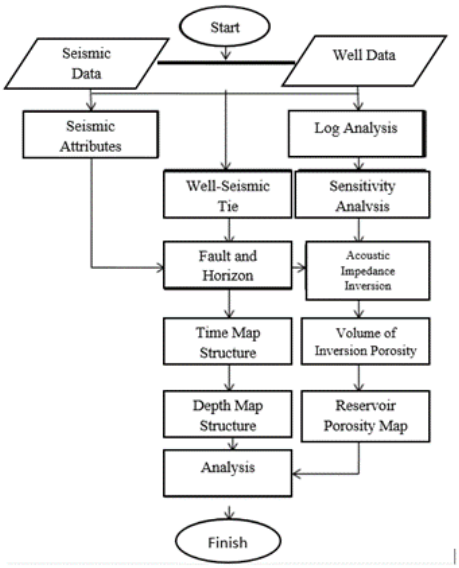

Figure 3: Flow Chart of the Study

Seismic attributes and acoustic impedance inversions are used to analyze physical lithology and the presence of reservoir hydrocarbon fluids.

Result and Discussion

- Well Log Analysis Cross plot Analysis

The results of the log response can be clearly seen the presence of KF prospect areas in carbonate tuban formations that are stratigraphically carbonate rocks precisely from the range of 2152 ms - 2450 ms. Figure 4 shows the result of P-wave log analysis and density logs in KF wells.

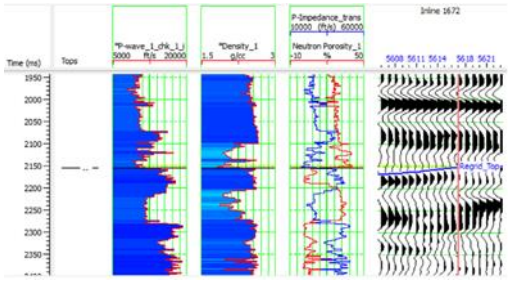

Figure 4: The Result of P-wave Log Analysis and Density Logs in KF Wells

- Cross plot Analysis

Cross plot analysis was conducted to present all acoustic impedance values on top carbonate to base carbonate precisely at a time of 2152 ms to 2450 ms with acoustic impedance values ranging from 24.000 ((ft/s)*(g/cc)) – 56.000 ((ft/s)*(g/cc)). Figure 5 is the result of cross plot analysis of neutron porosity log and P-impedance log.

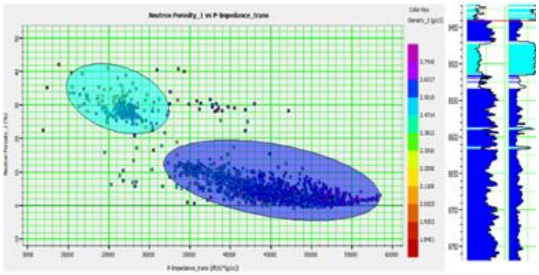

Figure 5: The Result of Cross plot Analysis of Neutron Porosity Log and P-impedance Log

The circled zone in light blue is a target zone with an Acoustic Impedance value of around 24,000((ft/s)*(g/cc)) - 32,000((ft/s)*(g/cc)) that has a high neutron porosity of 22% – 44%. While the dark blue circled zone is a bad reservoir zone in the range of acoustic impedance values >33,000 ((ft/s*(g/cc)) which has a range of neutron porosity values <15%.

- Well-Seismic Tie

Well Seismic Tie is a process of binding seismic data with well data that aims to equalize seismic domains in the form of time into the depth domain of well data. The ultimate aim of this binding process is to find out the position or reservoir horizon of Tuban carbonate on seismic data so that when picking the seismic horizon can be done precisely.

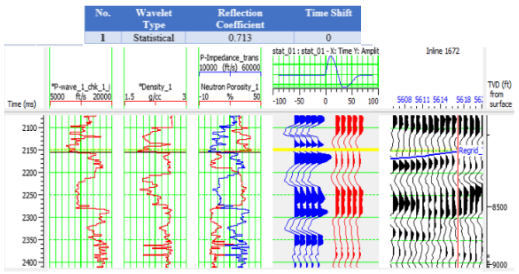

Figure 6: Well Seismic Tie Result

- Instantaneous Phase Attributes

The result of the extraction of this instantaneous attribute is a cross-section of seismic that aims to show the continuity of the layer laterally and the irregularity of the seismic trace (Figure 7).

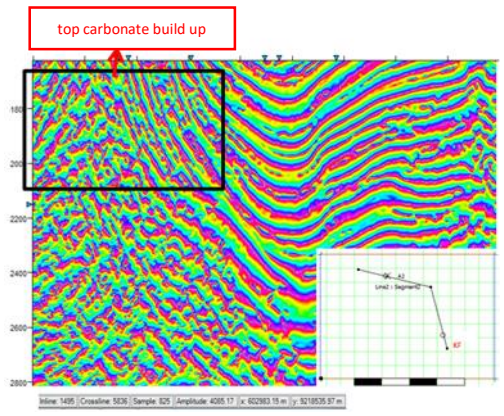

Figure 7: Cross section results trace instantaneous phase attribute

The area in the black box is the result of extraction of the attributes of the targeted research area so that it will make it easier to find the top build up carbonate. The inversion process is carried out on the top tuban of the carbonate reservoir.

- Acoustic Impedance Inversion

The inversion process is carried out on the top tuban of the carbonate reservoir. Control well data in performing inversion is well data that penetrates the entire Tuban carbonate formation, namely KF wells. The main purpose of the inversion is to see the lateral distribution of the acoustic impedance value derived from the KF well to the KF prospect area. The inversion method used is the Inversion Based Model (Figure 8).

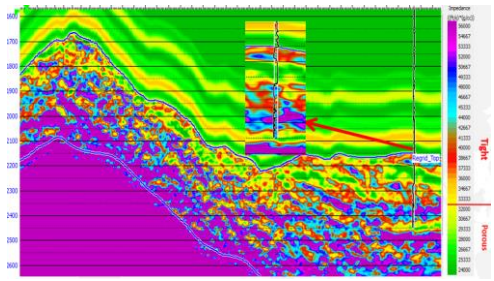

Figure 8: Acoustic Impedance Inversion Cross-Section Result

The distribution of low acoustic impedance values and high acoustic impedance values at each depth, where low acoustic impedance values are green - yellow and high acoustic impedance values are blue-purple. The effect of changes in acoustic impedance (AI) values can be analogous to rock hardness and inversely proportional to porosity. The inversion results are separated by a range of low and high acoustic impedance values. Where the target acoustic impedance value is a low value ranging from 24,000 - 32,000 ((ft/s)*(g/cc)) which is green - yellow, it has a higher porosity. While the range of high acoustic impedance values between >33,000 ((ft/s) (g/cc)), it has a smaller porosity. This is because the existing structure in the prospect area has differences that cause differences in the acoustic impedance value of the inversion process.

- Porosity Volume

The volume of porosity is done to find out the actual porosity value that exists in the target area. The distribution of carbonate porosity values in seismic volumes is derived from the conversion of acoustic impedance values to porosity values through the equation on the cross plot between the P-Impedance trans log and the neutron porosity log. The equation produces a mathematical equation: y = mx + c (-0.00100642 x AI + 51.0727). The mathematical equation is then used to convert the volume of acoustic impedance into the volume of porosity (Figure 9).

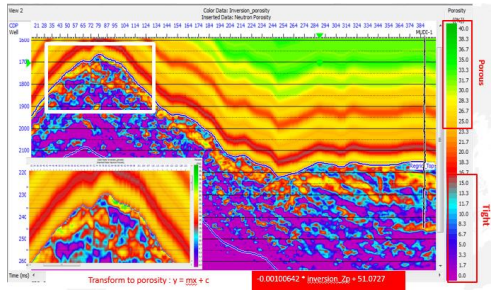

Figure 9: Cross Section of Porosity Volume Distribution

The range of small porosity values is purple – light blue which has a value of <15% indicated as shale rock, while high porosity is red – green which has a range of values ranging from 25% - 40% indicated as rock carbonate.

- Proposed New Well

This carbonate reservoir dispersal pattern is further used to plan the location of the most optimal new well. The conclusion of the location of the most optimal well exploration is done by looking at the distribution pattern of the spread of high dominant porosity values of 25%-- 40% scattered on the top carbonate (green color) which is interpreted as the best reservoir accumulation area where the area is geologically indicated as carbonate build up, so that the most optimal and detailed well prospect zone can be obtained.

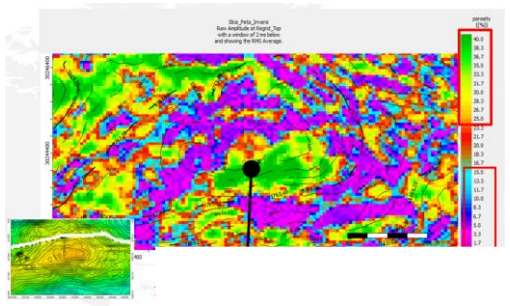

Figure 10: Map Of the distribution of porosity distribution and the location point of the proposed new well (black)

The location of the new proposed well point is depicted with a small black circle symbol on the map. If viewed from the point of the location, it is around the seismic cross-section on inline 1495 and xline 5830.

Conclusions

Based on the results of processing and interpretation of data on research that has been done on KF Prospects it can be concluded that low Acoustic Impedance values ranging from 22,000 - 32,000 ((ft/s)*(g/cc)) have porosity ranging from 25 - 40%. While the high Impedance value of >33,000 ((ft/s)*(g/cc)) has a smaller porosity <15%. The best well position on the KF prospect is right on the Top carbonate at inline 1495 xline 5830 depth of 6000 ft

References

Brown, A.R. 2000. AAPG Memoir 42 SEG Investigations in Geophysics, No. 9, Oklahoma

Ellis, Darwin V., and Singer Julian M. 2008. *Well Logging for Earth Scientist. Netherlands.*

Pertamina BPPKA, 1996. *Petroleum Geology Of Indonesians Basin : Principles, Methods, And Application, Vol IV : East java basin*. Pertamina BPPKA

Rider, Malcolm. 1996. *The Geological Interpretation Of Well Logs Second Edition*. Scotland : Interprint Ltd

Russell, B.H. 1988. *Introduction to Seismic Inversion Methods*. Calgary. Canada

Russell, B.H. 1991. *Introduction to Seismic Inversion Methods*, third edition, Volume 2, S.N. Domenico, Editor Course Notes Series

Sukmono S. 2007. FIKTM, Institut Teknologi Bandung

Veeken, P.C. H., 2007. *Seismic Stratigraphy, Basin Analysis and Reservoir Characterisation*. Amsterdam: Elsevier

Van Bammelen. 1948 *The Geology Of Indonesia* Vol. IA. Government Printing Office The Hague

Acknowledgements (Optional)

The author thanked PT. Pertamina Hulu Energi which has given permission to publish it as well as the UIN Walisongo Semarang Physics Study Program which provides full support