Reservoir Properties Modeling Using Multi-Attribute Seismic Analysis: Case Study South Sumatra Basin

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Abstract. Seismic inversion and multi-attribute analysis method are used in this research to characterizes the reservoir properties. Where both of these methods will be resulted an acoustic impedance volume and log property volumes. The property log volumes were created from density, porosity, Gamma-Ray (GR) and Water Saturation (Sw) log. There are 4 wells that is used in this research, they are EM-31, EM-32, EM-33 and EM-34 and a 3D seismic data post- stack time migration. Based on a map of acoustic impedance distribution, the reservoir target has an acoustic impedance value of 6.000 ((m/s)*(g/cc)) to 8.000 ((m/s)*(g/cc)). Furthermore, based on the map of the distribution of the log property, reservoir has a density value with a range of 2.3 g/cc up to 2.4 g/cc, porosity value > 10%, GR value of less than 100 API and Sw 50% to 55%. Thus, it can be concluded that reservoir has a lithology of sandstones, has a fairly good porosity and contains oil fluids.

Keywords: multi-attribute seismic, reservoir, south sumatra basin, modeling

1. Introduction

The high demand for oil and gas needs is to encourage gas companies to take an exploration stage in discovering new reserves. Many studies and research have been conducted in recognizing the reservoir character. To perform characteristic reservoir there are several methods that can be used. They are seismic inversion method and multi-attribute analysis method.

According to [1] seismic inversion method is an inversion technique in the form of a geological condition to the back (invers modelling), this method provides the results of the underground geological appearance, so as to identify the character and distribution of the reservoir on the target area in the form of the interpretation of geological, lithology, and fluid.

Multi-attribute analysis is a method of analysing the relationship between well data and seismic data at the location of wells in performing the volume estimation of log properties on the overall seismic volume. This method is a method which uses many attributes to predict some of the log properties of which are porosity [2][3][4].

In this research, the characteristic analysis of reservoir is done based on acoustic impedance distribution map and the map of the log properties that will be conducted analysis on the location of lead

zone reservoir. The data generated in this study which was obtained from the Acoustic Impedance (AI) inversion process and multi-attribute analysis can be used to create a log property distribution in the research area that will be able to be known characteristic of the location indicated as reservoir containing hydrocarbons in it.

2. Regional Geology
The basin of South Sumatra is a basin bordered by the Tiga Puluh mountains to the northwest separating the South Sumatra basin and the Central Sumatran Basin, the Sunda display is in the northeast, Barisan and the Sumatran Fault in the southwest, and Lampung High in the southeast. Figure 1 shows the column stratigraphy of the southern Sumatran basin, it appears that the Baturaja formation above from the Talang Akar formation, the Baturaja formation itself consists of limestone and has a varying thickness of about 60 – 75 mm, while the Talang Akar formation itself is above the Lahat formation and Baturaja formation, consisting of sandstone that comes from the delta plain, silt, quartz with coaly carbonaceous intercalated claystone and in some places there is a conglomerate. The thickness of the Talang Akar formation around 460-610m.

Figure 1. Stratigraphy column South Sumatera Basin[5].
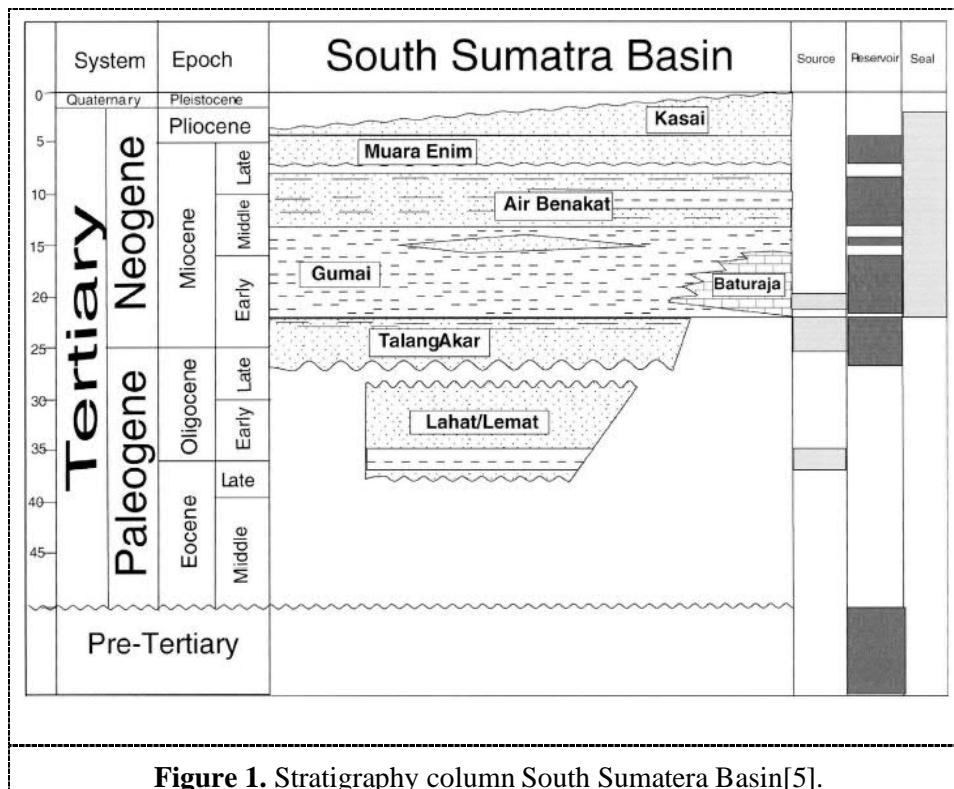
3. Methods

3.1. AI inversion
The AI inversion is done by analysing the data sensitivity of the well, where this stage serves to determine the value of the acoustic impedance as to what indicates the hydrocarbon lead zone in the research area. This analysis of sensitivity is done by creating a cross-plot between the log AI and other logs. Therefore, the cross-plot results will be known as the AI value range that shows the lead zone of the Reservoir and create the initials model (initial model). Then after the initials model is obtained, then perform a pre-inversion analysis. Pre-inversion analysis is done for simulation or control to perform

inversion stage, that to know the best inversion results to be obtained. Once considered pre-inversion results are already good. Next, apply the inverse result of all well at the seismic volume as a whole by applying the parameters at the pre-inversion stage[6].

3.2. Multi-attribute analysis
Multi-attribute analysis is an analysis of the relationship between seismic data and well data that will be used to perform a volume estimation of log properties on the overall seismic data volume[7]. Multi-attribute analysis uses multiple attributes in predicting multiple log properties from the log data used, in conducting multi-attribute analysis of used seismic data, the log data being targeted, internal seismic attribute data as well as seismic external attribute data. In this study, the log target is density log, porosity log, Gamma Ray (GR) log, and Log saturation water (Sw). The initial stage is to perform a single attribute analysis, which will be cross plot next to each attribute with the target log property. Then, perform multi-attribute analysis by using the step-wise regression method, in this step channelled the determination of many good attributes is used based on the validation error values.

4. Results and Discussion
The prospect zone of hydrocarbons in the well data has a low gamma ray value, and there are crosses or separations between low density (RHOB) and low NPHI. If viewed from Based on qualitative analysis, it can be concluded that the coating with a good indication of hydrocarbon is the layer of BRF, A0 and A and A2. However, due to the layers of A0 and A2 is a thin layer, the research is focused on the layers of BRF and A.

This Sensitivity analysis is done before doing an inversion of the inverse, which from the analysis result of the data logs This will provide an information about the relationship log AI data with other data logs. From the sensitivity analysis results that have been done before, it is noted that the target zone has an acoustic impedance value of 6000 (m/s)*(g/cc) to 800 (m/s)*(g/cc), density value 2.4 g/cc to 2.3 g/cc, porosity value > 10%, GR value < 100 API as well as Sw value < 70%. Good inversions can be seen quantitatively by looking at the parameters of the RMS error, the correlation coefficient as well as the relatively minor errors. According to Table 2 that the correlation value that has been produced has a strong quality according to Schober et al. (2018) [8] which is above 0.9 which is followed by an RMS *error* value of 400 to 480 and has a relative error value less than 0.5. Where this indicates that the pre-inversion analysis performed is reasonably good, which further applies the pre-inversion results to inversion the overall seismic data volume.

Multi-attribute analysis carried out as many as 4 log targets, namely density, porosity, GR, and Sw (figure 1). This multi-attribute analysis uses the step wise regression and probabilistic neural network (PNN) methods. The step wise regression method is a method that includes both internal and external attributes that serve to produce a model capable of matching the target log. While the PNN method is a method that performs analyses with non-linear methods. The parameter that should be observed in conducting multi-attribute analysis is the number of attributes to be used, the *error* validation value and the resulting correlation value. As for the research the initial attributes are used as much as 10 attributes. After, obtaining the attribute to be used, the cross-plot stage is performed to find out the relationship of the original density log and the predicted density log of the results from the multi-attribute analysis. Then, subsequent results are multi-attributes by using the about regression method and the PNN method compared to each other. From the results of the analysis process generated multi-attribute log prediction of density logs, porosity, GR, and Sw. Further, applied to the seismic data volume. Then, the slicing is done on the BRF and A layers and generating a spread of property log.

4.1. Discussion
The characteristic analysis of Reservoirs is performed to determine the nature and distribution and character of reservoir in seismic data relating to log data. In conducting analysis, the characteristic

reservoirs are carried out based on a map of the log AI distribution, the map of the density log distribution, the map of gamma ray log distribution, and the map of the Sw log spread on the zone considered as the lead zone. Based on a *log* sensitivity analysis that has been done that the target zone has an AI value of 6000 (m/s)*(g/cc) to 8000 (m/s)*(g/cc). Where the wells of EM-31, EM-32, EM-33 and EM-34 showed an acoustic impedance value of 6000 (m/s)*(g/cc) on the BRF layer. On A layer indicates that the EM-32 well has an acoustic impedance value of 8000 (m/s) * (g/cc), for the wells of EM-31, EM-33, and EM-34 has an acoustic impedance value of 7250 (m/s) * (g/cc). So that it can be concluded based on the acoustic impedance value map that the lead zone has an acoustic impedance value of 6,000 (m/s)*(g/cc) to 8,000 (m/s)*(g/cc). On the map of the BRF layer that the density value of the lead zone consists of the EM-31, EM-32, EM-33 and EM-34 amounted to 2.3 g/cc. Whereas, on a map of the layer A density value in the lead zone of 2.4 g/cc.

Table 2. Quantitative Pre-Inversion Analysis

Well	RMS *Error*	Coefficient correlation	*Relative Error*
EM-31	465.367	0.986	0.265
EM-32	450.527	0.902	0.437
EM-33	411.481	0.978	0.214
EM-34	477.147	0.993	0.258

On The map of the porosity of the wells of EM-31, EM-32, EM-33 and EM-34 that porosity value is above 10%. Hence, it can be concluded that the porosity owned by the lead zone has a quality that is according to that Wei (2016) [9]. Based on the GR distribution map that the prospect Zone is a zone that has a moderate to moderate radioactive value, which is correlated with the density value that the lithology in the lead zone is the lithology of sandstones. Based on a map of the SW range, That the Sw value in the lead zone on the BRF layer for the EM-31 wells, the EM-33, the EM-34 indicates a Sw value of 0.55 or 55% while the EM-32 well indicates a Sw value of 0.5 or 50%. At layer A Sw value at the well EM-31, EM-32, EM-33, and EM-34 show a value of 50%. As it is known according to Wibowo (2020) [10], that the value of Sw < 0.25 is oil and gas fluid, Sw 0.25 – 0.75 is oil fluid, and > 0.75 is water fluid. It can be concluded that the Sw value in the lead zone is a zone that has fluid in the form of oil. However, judging from each map, the zone that will be used as the target zone has not been clearly visible, making it difficult to determine the location of the lead zones. Thus, a method can be demonstrated that the location of the lead zone is targeted in accordance with the value of acoustic impedance, density, porosity, GR and Sw, where the method is spatial analysis method, which combines five maps into one.

Spatial Analysis method is conducted by classifying acoustic impedance distribution map, density map, porosity map, GR map and Sw map which are classified as 0 and 1. Where 0 is declared as an area that is not a prospect and 1 is declared as the lead area. A zone declared as the hydrocarbon prospect Zone is an eligible zone having an acoustic impedance value of 6,000 (m/s)*(g/cc) to 8,000 (m/s)*(g/cc), the density value is 2.3 g/cc-2.4 g/cc The value of porosity > 10%, GR value < 100 API and the average Sw value – average 50%-55%. From the analysis that has been done on the lead zone distribution map of the area BRF that indicates hydrocarbons are located in the north to the east of the map and on layer an area that indicates hydrocarbons are located in the north to the northeast of the map.
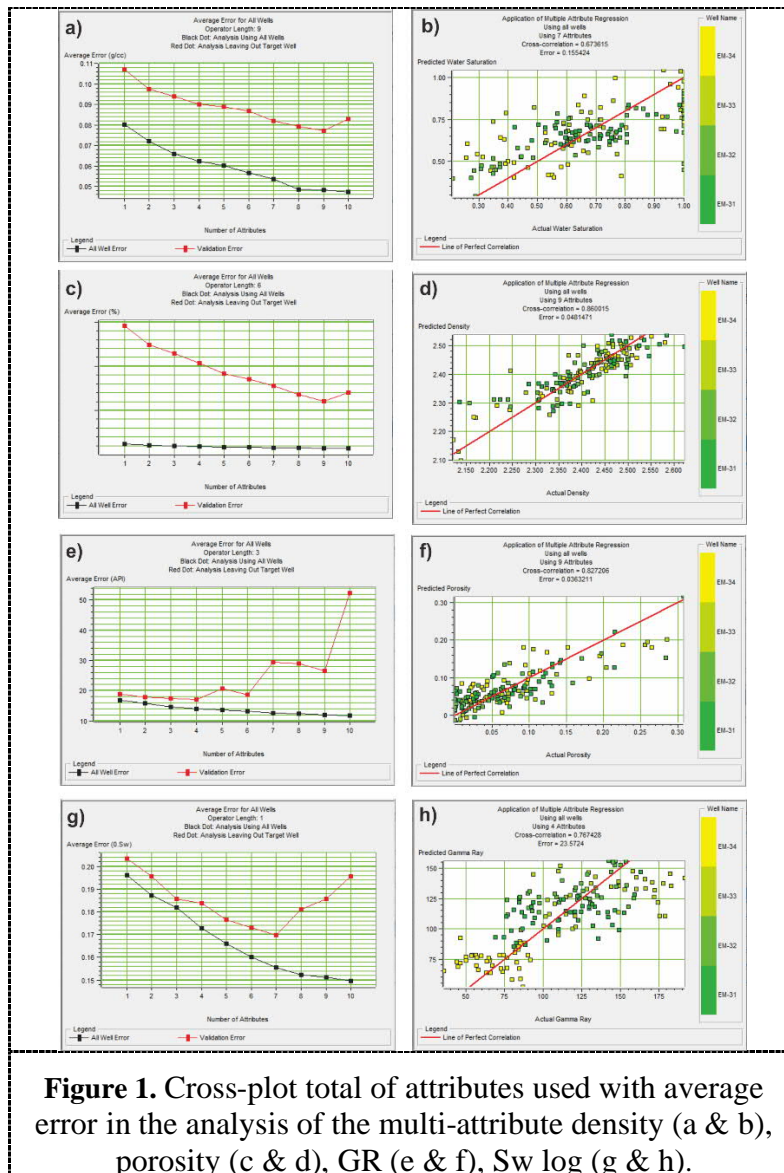
Figure 1. Cross-plot total of attributes used with average error in the analysis of the multi-attribute density (a & b), porosity (c & d), GR (e & f), Sw log (g & h).

5. Conclusion

From the results of the research, it is obtained the following conclusions:

a) The result of the volume of AI inversion and the volume of the Log property that has been made have good quality, indicated by the average correlation value in the output of AI of 0.959, multi-attribute analysis of density log of 0.744, multi-attribute analysis of the logs of 0.797, a multi-attribute analysis of the gamma ray log of 0.732 and a multi-attribute analysis 0.744 of Sw.

b) It is known that the spread of property logs is performed on the BRF and a layer which are the target zones in this study. Based on acoustic impedance distribution map and log property distribution map, that in the lead zone has an acoustic impedance value of 6,000 (m/s)*(g/cc) to 8,000 (m/s)*(g/cc), density of 2.3 g/cc to 2.4 g/cc, porosity > 10%, GR < 100API and Sw average 55%.

c) Analysis that has been done on the layer of BRF area that indicates hydrocarbons are in the north to east of the map and on layer a area that indicates hydrocarbons are in the north to the northeast of the map.

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