Acoustic impedance model-based inversion to identify target reservoir: a case study Nias Waters

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Abstract. Seismic method is a good geophysical method in imaging the subsurface conditions using the principle of seismic wave propagation. This method is often used in hydrocarbon exploration. One important step in hydrocarbon exploration is seismic interpretation. In the stages of seismic interpretation, a good basic knowledge of geophysical and geological knowledge is needed regarding the existence and characterization of hydrocarbon reservoirs. One method used in interpreting seismic data is the acoustic impedance inversion method. In this study, 2D seismic inversion was carried out to determine the reservoir characteristics of the MCL-1 well in the Nias basin. This study uses model-based on inversion which aims to obtain the value of acoustic impedance which is useful for the identification of distribution, porosity values and reservoir conditions of the target zone. The results obtained are the target reservoir zone at a depth of 6649-7434 feet or 1705-1810ms for MCL-1 wells with a range of acoustic impedance values of 25556 ((ft/s) * (g/cc)) - 46885 ((ft/s) * (g/cc)) with the type of rock that fills the reservoir is the type of limestone rock. The correlation value for model-based inversion has a relatively small error. This can characterize the hydrocarbon reservoir well.

1. Introduction

The high demand for energy, especially in the oil and gas sector. Make oil and gas companies try to increase oil and gas production. For this reason, it is necessary to carry out exploration activities on an ongoing basis with appropriate methods so that they can describe the conditions under the earth's surface. The method that is considered the most appropriate in describing the subsurface geological conditions is to use a seismic method. This method can characterize the hydrocarbon reservoir to be well known. Reservoir characterization is important to do especially to see the subsurface of oil and gas reservoirs. According to [1] reservation characterization is a process to describe quantitatively and/or qualitatively using all available data. However, there are many disturbances due to the complexity of the structure of the earth's layers, so it is necessary to increase the resolution and improve the estimation so that the reservoir can be well characterized.

The technique that can be used is inversion technique, inversion technique is a technique that can characterize the reservoir by creating a geological subsurface model recorded by the tool by using seismic data in horizontal distribution media and well data as a control [2]. In determining reservoir characterization can be done by looking at the distribution of impedance. The method that is widely used in this case is the acoustic impedance inversion seismic method. Acoustic impedance (AI) seismic inversion is the ability of rocks to pass seismic waves which are multiplications of rock density and velocity [3].
2. Methods

2.1. Seismic reflection
Seismic reflection is one of the geophysical methods used in exploration especially hydrocarbons by utilizing elastic waves as a medium of interpretation. In principle, the reflection method utilizes elastic waves that are injected by the source which then propagate through a medium (earth) and the results of the propagation are in the form of responses captured by the receiver as shown in figure 1. The response will provide information about subsurface lithology. The information carried is translated into a form of travel time (travel time) which will give an idea of the velocity of the wave propagation in the rock layers traversed, amplitude, frequency and phase variations.

Where $AI$ is acoustic impedance value, $\rho$ and $V$ are density (g/cc) and wave velocity (ft. s$^{-1}$). $S$ and $R$ are source and receiver. The $x$ value indicates distance between sources until receiver.

2.2. Seismic inversion method
In the seismic inversion method, the seismic cross section is converted to an acoustic impedance that represents the nature of the rock. According to [5] the seismic inversion method is a technique for creating subsurface models using seismic data as input and well data as a control. The process carried out in this method can be said as backward modelling (figure 2).

Figure 1. The concept of transmitting seismic waves from source to receiver [4].

Where $AI$ is acoustic impedance value, $\rho$ and $V$ are density (g/cc) and wave velocity (ft. s$^{-1}$). $S$ and $R$ are source and receiver. The $x$ value indicates distance between sources until receiver.

Figure 2. various kinds of seismic inversion methods [5].

[6] divides the inversion seismic method into two groups, namely pre-stack inversion and post-stack inversion. Pre-stack inversion can be used to see the effect of fluid that can give the effect of changes in amplitude to offset. While some post-stack inversions are recursive inversion, sparse spike, and model based. According to [5] there are three types of inversion methods commonly carried out in seismic data inversion, the process is as follows:

In this study the inversion method used is a model-based method, the principle of this method is to make a geological model and compare it with real seismic data. Model-based inversion methods can
restore lost low and high frequencies by correlating seismic data with seismic responses from geological models.

2.3. Acoustic impedance

In principle, the final result of the seismic data inversion process is in the form of acoustic impedance data which has more complete information than seismic data. Acoustic impedance is the ability of rocks to pass seismic waves through it. Physically, Acoustic Impedance (AI) is a product of the compression wave velocity (Vp) with rock density (ρ). The harder a rock is, the greater its acoustic impedance, for example: a very compact sandstone has a higher Acoustic Impedance compared to clay stone. Mathematically the acoustic impedance of a rock is the result of multiplying the velocity with the density value of a rock, so it can be written:

\[ AI = \rho \times V_p \]  

2.4. Migration

In the process of seismic data acquisition there are many disturbances or noise originating from both instruments, wave propagation and from the environment. This noise can be in the form of diffraction, multiple and bowtie effects which make the subsurface image unclear and inaccurate. The seismic profile produced in a complex structure must be detailed to look like an actual subsurface structure. There are some corrections that can be used to process seismic data so that the resulting image has good quality and can minimize or eliminate noise, one of which is migration [7].

2.5. Study area

Data acquisition was carried out by the Center for Marine Geological Research and Development (PPPGL) of Indonesia in 2018 using a R.V. Geomarin III equipped with multichannel seismic devices in Nias waters. Map of the research location can be seen in figure 3.

Figure 3. Seismic lines map.
2.6. Data analysis procedure

Data processing is divided into several stages, namely, data preparation, seismic data processing, well data processing, seismic data binding, sensitivity analysis, horizon tracking, acoustic impedance inversion modeling which will then be interpreted, flow charts can be seen in (figure 4).

![Flow chart of seismic data processing](image)

**Figure 4.** Flow chart of seismic data processing.

2.6.1. Data preparation. The data preparation process includes seismic data and well data, determining seismic lines and wells used and viewing log information that must be present in each well.

2.6.2. Seismic data processing. Seismic data processing begins by entering raw data (SEG-D extension) into a database on ProMAX, then doing, de multiplexing, geometry, trace editing, true amplitude recovery (TAR), surface wave attenuation, deconvolution, velocity analysis, NMO / stacking and migration. The stages are carried out so that the quality of the seismic cross section has a high SNR and lateral resolution.

The initial step in data processing is data input. The data to be processed has the SEG-D extension, which is data that has not yet been processed. SEG-D data are generally digital data acquired on the ground per shot / shot which are then combined into one group each line, called shot gather. The data is included in a dataset in ProMAX. Complex surface conditions because the received signal to vary, so a
bandpass filter can be performed. In the process of inputting this data can carry out the process of sorting trace seismic data. This is done to remove traces that are damaged before entering into the next process.

The second stage is geometry. Geometry stages are carried out to determine the actual position of the acquired track. Without the correct geometry the track will miss its proper position, of course this will affect the next stage. Information about the geometry will be an identity of the recorded seismic trace, so that geometry becomes a very vital attribute in seismic data processing. To facilitate the presentation of seismic data, it is necessary to add other data acquisition parameters such as shot point coordinates, receiver coordinates, CDP coordinates, CDP numbering, offset, and others. Data acquisition parameters on paths L21, L22 and X24 can be seen in Table 1.

| Line name          | Unit    | L21  | L22  | X24  |
|--------------------|---------|------|------|------|
| Shot Point         | degree  | 1324 | 1262 | 430  |
| Azimuth            | degree  | 333  | 153  | 245  |
| Active Channel     | 1-96    | 1-96 | 1-96 |
| Source Depth       | m       | 6    | 6    | 6    |
| Receiver Depth     | m       | 7    | 7    | 7    |
| Shot Interval      | m       | 25   | 25   | 25   |
| Group Interval     | m       | 12.5 | 12.5 | 12.5 |
| Near Offset        | m       | 50   | 50   | 50   |
| Far Offset         | m       | 1237.5 | 1237.5 | 1237.5 |
| Distance Between CDP | m    | 6.25 | 6.25 | 6.25 |
| Total Length       | km      | 33.075 | 31.525 | 10.725 |

The third step is trace editing. Trace editing is the process of removing data that is considered damaged or can interfere in the subsequent data processing. Seismic data recorded does not only contain the primary signal, but sometimes it is mixed with noise. Recorded noise can cause ambiguity of data so the trash editing stage needs to be done to eliminate noise and increase the S / N ratio of seismic data. The steps of editing the trash carried out are trace muting, trace length and band pass filter.

The fourth stage is True Amplitude Recovery (TAR), in essence is to restore the energy lost due to the attenuation of wave energy during propagation. Absorption of wave energy is caused by geometrical spreading factors and the character of the rock being passed through. When processing data, this attenuation factor can be recovered by the True Amplitude Recovery (TAR) process using dB / sec correction.

The fifth stage is the Surface Wave Attenuation. Surface Wave Attenuation is used to attenuate noise originating from surface waves by forming a low frequency array.

The next process is deconvolution which will increase the temporal resolution of seismic data. Deconvolution is carried out to restore the wavelet form of data to the reflector wavelet form, eliminating multiple short periods and reverberation effects. Deconvolution used is predictive deconvolution. Important parameters in predictive deconvolution are the prediction distance operator value and the decon operator length used to suppress multiple short periods. Deconvolution can be used to increase broadband seismic data frequencies, make wavelets become more spike and control multiple existence. Seismic tracis can be considered as the result of convolution between the reflection coefficient and seismic signals.

The next stage is the F-K filter method which is a filter in the frequency domain and wave number (fk). The filter will convert seismic data from time and distance (t-x) domains to frequency and wave number domains using Fourier transform. F-K filter can be used to filter the desired signal by creating polygons (f-k gates) on all FFID in the fk domain. To map multiple waves can be done by the polygon picking process in the FK analysis window.

Surface Related Multiple Elimination (SRME) method is a method to eliminate surface-related multiple contained in seismic data. The SRME method utilizes the reflections contained in post-stack
seismic data to predict surface-related multiple, several stages of the SRME method, namely: water bottom picking, offset reconstruction, multiple models, and adaptive subtraction. ProMax software describes these stages into several modules, namely: SRME Regularization, SRME Macro, SRME Un-Regularization, SRME Match Filter, and SRME Adaptive Subtraction.

The next stage is migration, migration is carried out to return the reflector to its actual position so that the seismic section can represent the actual geological conditions based on the reflectivity of the earth's layer. Migration used in this study is Post-stack time migration, which is the migration process after stacking in the time domain. The migration process carried out after the stack is relatively faster and efficient in processing seismic data [8]. The method used in the POTM stage is the Post-stack Kirchhoff 2D Time Migration method.

2.6.3. Well data processing. Data needed for processing well data is sonic log, density and check shot so as to produce synthetic seismograms. Sonic log data and check shot are used in binding data wells with seismic data. This is needed because there are domain differences between well data and seismic data. Seismic data are generally in the time domain and well data are in the depth domain. The available log well information can be seen in (Table 2).

Table 2. Description of well logs used.

| Well  | Log       | Checkshot |
|-------|-----------|-----------|
| MCL-1 | GR CALI SP IND SN RHOB NPHI DT PROX |

Description: GR (Gamma Ray), CALI (Caliper), SP (Spontaneous Potential), IND (Induction Deep Resistivity), SN (Short Normal Resistivity), RHOB (Compensated Formation Density), NPHI (Neutron Log Porosity), DT (P-Wave), PROX (Proximity).

2.6.4. Well seismic tie. Binding of well data to seismic data is carried out to integrate well data in the depth domain with seismic data in the time domain. In the binding needs to be done from the time domain depth domain conversion using check shot. In the binding process, wavelet is one of the most important things. Where the more suitable wavelet is used, the more match between synthetic with trace seismic. Based on well data, synthetic seismogram will be obtained and based on seismic data, seismic cross section will be obtained. Seismic cross sections are made by convoluting the source wavelet with the reflection reflector coefficient in the earth. Wavelet type used in this research is statistical wavelet. This wavelet is created by extracting statistical seismic wavelets. To get a good correlation, shifting and stretching are done, when stretching is expected not to be excessive because the stretching process can change the log data.

Synthetic seismograms that have been made are then bound with seismic data. This binding will produce a correlation coefficient between seismic data and synthetic seismogram so that there is conformity at the time of the search, so that the horizon is at the actual depth. Correlation results from binding data wells with seismic said to be good if approaching 1 with a time shift approaching 0 or equal to 0.

2.6.5. Sensitivity analysis. Sensitivity analysis was performed using log data cross plots. This is done to determine the relationship of parameters in the X and Y axis in the log and to know whether or not inversion analysis can be done at that interval. The more sensitive the log is with the crossed plot, the clearer the cut-off zone will be so that lithology and fluid types can be determined in the reservoir.

2.6.6. Picking horizon. Picking horizon is carried out to trace the continuity of the horizon identified through the target zone in the well. Picking horizon is very important because horizon tracing is used as a lateral control of seismic data that will be used to model the initials of the earth at the inversion stage.
Horizons traced numbered two, namely the horizon which is the upper boundary of the target zone and the horizon which is the lower boundary of the target zone.

2.6.7. Build initial model. The initial model was created using 2D seismic cross section, wavelet analysis results, the upper limit of the horizon in the target zone (horizon 1), the lower limit of the horizon in the target zone (horizon 2), and log data. The log data used is the acoustic impedance log data. The acoustic impedance log data is obtained from the sonic log (speed log) and density log. The initial modeling was carried out in the 'MCL-1' well with three passes (L21, L22, X24).

The trajectory that will be carried out for making the initial model is chosen the path that is close to the well or crossed by the well. This is done so that there is vertical control over the initial model. The initial model and seismic data determine whether the inversion results are good or not.

2.6.8. Inversion process. After making the initial model, the analysis is carried out before inversion. This analysis is done by using band limited and model-based inversion which will then get the value of correlation and error between the initial model and the results of the inversion. To get a high correlation value a matching wavelet is needed on the well. But besides wavelet extraction there are several parameters that need to be changed to get a high correlation value. These include: sample rate, horizon, and acoustic impedance well log data used, average block size, soft constraints, and number of iterations used. The magnitude of this correlation value will affect the results of the inversion, because the higher the correlation value, the inversion results will be better.

3. Result and discussion

3.1. Target zone identification

Target zone identification is done to determine the composition of rocks that are in the reservoir zone. In this case the MCL-1 well is used, in the MCL-1 well the measurement starts at a depth of 250 feet (76.2 m) and ends at a depth of 8930 feet (2721,864 m) with a measurement depth of 8680 (2645,664 m) with a Kelly Bushing elevation value of 31 feet and ground level elevation of -213 feet.

One of the data that can be used in determining reservoir zones is log data, using quick look evaluation, which is a qualitative brief evaluation based on the response of existing log data to distinguish lithology and predict target zones. Logs that can be used in determining the target zone are the gamma ray (GR) log, resistivity log, sonic log (P-wave), and the results of the neutron porosity log and density log (RHOB) crossing. The existence of a reservoir is characterized by relatively low gamma ray (GR) values [9], gamma ray log (GR) can distinguish permeable and non-permeable lithology. Log resistivity can determine the type of hydrocarbons by looking at the high and low resistivity response to lithology. Another log used in determining reservoir zones is the sonic log, the sonic log depicts the speed of sound emitted into the formation until it is recaptured by the receiver. Sonic logs will propagate rapidly in solid material and slow in gas material. Reservoir identification can also be determined by looking at the crossing curve spacing between the porosity log and the density log, the more positive the separation of the log curve and the porosity log density is, so it can be assumed that the hydrocarbons contained therein are gases [10]. So, by analyzing this primary log the reservoir potential zone can be determined.

Based on the log data the target zone in the MCL-1 well is predicted to be between claystone and sandstone that is from a depth of 6649 feet to 7434 feet with a layer thickness of the MCL-1 target zone of 785 feet and a time span from 1705ms to 1810ms with the constituent rocks are limestone (limestone). The zone can be considered as a target because it has a low gamma ray value, high resistivity and a change in impedance value. The target zone in the MCL-1 well can be seen in figure 5.
3.2. Analysis of tuning thickness

Tuning thickness analysis is performed to determine the thickness of the reservoir that can be properly dissolved by seismic waves. Tuning thickness is one type of vertical seismic resolution. This resolution is related to the minimum distance between two different objects which can still be shown as separate objects. The ability to separate the two objects is influenced by the seismic wavelengths that pass through the rock. Rock thickness that can be distinguished by seismic waves has at least a thickness above $\lambda / 4$. This thickness is called tuning thickness. To determine the value of the thickness of the tuning required the average value of velocity (P-wave) and the dominant frequency of the waves in the layer [11].

The velocity data (P-wave), the average interval speed is calculated based on the target zone to be inverted. The MCL-1 well has an average velocity in the target zone of 4513.38 m/s with a thickness of the target zone of 239.26 m. Meanwhile, the dominant frequency value is obtained by extracting seismic data in the time window around the target zone. The dominant frequency extraction was carried out in the window of time 1706ms to 1810ms, with the dominant frequency value obtained was 19.5 Hz. Based on the calculation results obtained by tuning thickness value of 57.86 m so that the thickness of the layer is greater than the thickness of the tuning. This indicates that the target zone can be well revolutionized by seismic waves.

3.3. Sensitivity analysis of well data

Data sensitivity analysis needs to be done to see whether the data is feasible or not to be processed in the next step. Sensitivity analysis is used to determine the physical parameters that are most sensitive to data in distinguishing lithology and determining the presence or absence of fluid content in rocks. The technique used in analyzing data sensitivity is cross plot technique. The purpose of cross plotting is to determine the sensitivity of the two logs in the well data in the $x$ and $y$ axis, then the data that has a certain tendency will be zoning which illustrates the differences in lithology and the presence of fluid, then will be displayed through a cross-section so that zoning can be seen from the data lateral [12]. In conducting cross plot analysis, the log used is gamma ray log data, Impedance log, resistivity log, density log, and depth data.

Based on gamma ray (GR) log cross plots and impedance logs with color key depth data are used to view lithology of rocks in wells. The results of gamma ray (GR) log and plot impedance with color key depth data show that the cross plot can separate lithology in the target zone. The target zone is divided into two zones (figure 6). The blue zone has an impedance range of 26000-49000ft/s*g/cc and a gamma ray value of 10-34 API indicates that this zone is limestone. The red zone has an impedance range of 10000-19000ft/s*g/cc and a gamma ray value of 34-56 API indicates that this zone is shale.
This is reinforced by gamma ray log plot and density log with color key depth which has a range of density values of 2.26-2.68 g/cc and gamma ray log values of 10-34 API are limestone (blue zone), while gamma ray log values range between 34-56 API and the density range of 1.86-2.26 g/cc is shale (red zone). According to [13] when the gamma ray value is low and the density is high then there is a limestone and when gamma ray is high and the density is low then there is a type of shale rock.

Figure 6 indicates that there is a hydrocarbon fluid in the form of gas in limestone. This can be seen from the relatively high resistivity response in limestone (blue zone) so that it shows gas containing gas. The results of the cross section (figure 7) show a depth range of 2026.615 m-2265.883 m predicted as a place for the presence of gas hydrocarbons. Based on the sensitivity analysis using the cross plot technique, it can be concluded that the MCL-1 well has the potential of trapping hydrocarbon fluid in the form of gas in the limestone type (limestone). Known acoustic impedance as a physical parameter can separate rock lithology so that acoustic impedance values can be used for seismic inversion [14].

Figure 6. Results of well data cross plots to show (a) layer lithology and (b) fluid content in MCL-1 wells.

Figure 7. Gamma ray log cross plot and density log on a depth scale.
3.4. Well seismic tie analysis
In the binding process, wavelet is an important attribute in improving accuracy. Where, the more suitable the wavelet is used, the better the correlation is the binding of well data and seismic data. Wavelet extraction method used in the well seismic tie process in the MCL-1 well was carried out using the statistical method. The selection of this method is used because it has a high degree of accuracy compared to other types of extraction methods [15]. Wavelet used was extracted in 1705 ms -1810 ms window. Wavelet used is of zero phase type with wavelet length of 73 ms, 0 phase, sample rate of 2 ms, wave length of 146 ms with dominant frequency of 19.5 Hz. Figure 8 shows the results of wavelet extraction.

Wavelets that have been extracted are used in the process of binding well data and seismic data, these wavelets will play an important role in making initial models so it is necessary to obtain good correlation results. To get a good correlation done by trial and error. This repeated trial (trial and error) is mostly influenced by stretching and squeezing. The process of pulling (stretching) and contracting (squeeze) is the process of lengthening and shortening the value of time in seismic data in order to get the depth that matches the well data. When stretching, it is expected not to overdo it because the stretching process can change the log data. According to [16] 10 ms is the recommended limit for stretching and squeezing so that the well data does not change or shift.

The correlation coefficient obtained at well MCL-1 is 0.657 with time shift 0. The correlation results obtained at the target area have a correlation of more than 0.6, which means that seismic data and well data are matched [11]. This is reinforced by [17] that a correlation value of more than 0.5 means it has a close relationship between variables, the variable in question is a seismic cross section with synthetic seismogram.

Figure 8. Wavelet extraction results from statistical methods (a) time domain and (b) frequency domain.
3.5. Picking horizon
The results of searching horizons on seismic paths have good data quality and can clearly see the boundary between horizon 1 (blue line) and horizon 2 (green line). To get good data quality and obtain a clear continuity horizon, the seismic cross section is performed automatic gain control process in ProMAX software. Automatic gain control functions to eliminate the effect by returning the lost energy so that at each wave point comes the same amount in order to produce seismic data that is easy to interpret. However, not all horizon points can be traced clearly, so it is difficult to determine the horizon point. This is caused by the migration process used in this study, namely the post stack type migration process, so that the seismic data in the post stack will be stacked at zero offset resulting in the reduced amount of data [18].

3.6. Initial model
The initial model was created to model the initial inversion based on well data. Well data and log data are needed in making the initial earth model. The log used is the impedance log, which is obtained from the sonic log or speed log and density log. The initial model and seismic data determine the quality of the inversion results, because the initial model is used as a control in inversion. The initial model in this study was made at MCL-1 well, the results of the search horizon (horizon 1 and horizon 2), statistical wavelet, and high cut frequency used were 10/15 Hz. The results of the initials earth model in figure 11 shows the horizontal impedance values.
3.7. Pre-inversion analysis

The analysis is performed to see the correlation value between the impedance log of the well data and the impedance log of the inversion results and the fit value between the synthetic seismogram that has been obtained with seismic and look for the smallest error value in order to obtain a good correlation between the impedance value of the inversion results (red) and the value well data impedance (blue). The better correlation can be seen on the curve, if the curve is increasingly coincident, the value of the inversion results has a value close to the impedance value in the well.

The inversion used in this study is model based inversion, the results obtained show the results of model based inversions on the MCL-1 well in the target zone area on the curve do not show the impedance value curve which is coincidentally between the inversion results (red) and with the log well impedance (blue), this is because too many constraints are used so that the inversion log results experience a large impedance change. The constraint is a limitation of the extent to which the change in impedance of the inversion results is compared to the model determined by the limit [14]. With a total error of 9334.6. However, the synthetic seismogram data with the original seismic data shows a high correlation value, namely with a correlation value of 0.99, where the maximum correlation value is 1 so it can be said to have a very good correlation. With a specific error level of 0.05, the specific error level is close to 0, which means that the results of the pre-inversion parameter settings show good results. The results of these parameter settings can be seen in figure 12.

**Figure 11.** The results of the initials earth model.

**Figure 12.** Results of model-based pre-inversion parameter setting.
3.8. Analysis of inverse models of acoustic impedance lateral

The target zone obtained in the inversion results is at 1705 ms to 1810 ms with an acoustic impedance range of 25556 ((ft / s) * (g / cc)) - 46885 ((ft / s) * (g / cc)). Based on the justification of log characters and inversions that have been done, the range of acoustic impedance values is between 34000 ((ft / s) * (g / cc)) - 49000 ((ft / s) * (g / cc)) is a hydrocarbon prospect zone. Based on the crossplot it is found that the target zone is in the type of limestone containing gas.

The inversion results with the model-based method shown in figure 13 show a fairly good model in depicting subsurface geological models. However, the inversion results show that there are some parts of the color in the well and a less representative section of the acoustic impedance. It is suspected that the high content of clay rock at this depth can affect the sensitivity of the p-wave log reading [19]. The results of the inversion of acoustic impedance values tend to be homogeneous and relatively high. According to [20] the high value of geological impedance is caused by cementation in the rock layers so that the rocks will become denser or compact.

![Figure 13. Model-based inversion results in color acoustic impedance data.](image)

4. Conclusion

The results of applying the model based seismic inversion method on the MCL-1 well show a reservoir zone at a depth of 2026.615 m – 2265.883 m with a layer thickness of 785 feet and a time range from 1705 ms to 1810 ms with acoustic impedance values around 25556 ((ft / s) * (g / cc)) - 46885 ((ft / s) * (g / cc)) with the type of rock that fills the reservoir zone, i.e. limestone which is suspected to have a gas type hydrocarbon. Based on the correlation and error analysis of the results of the model-based inversion obtained a pretty good correlation, so it can be concluded that the model-based inversion is good enough to be used to characterize the hydrocarbon reservoir.

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