



Multi-attribute Seismic application for Modeling Static Reservoir In “Athran” Field South Sumatera Basin

Diah Wully Agustine¹

¹ Department of Geological Engineering, Institut Teknologi Adhi Tama Surabaya

e-mail: dwagustine@itats.ac.id

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Abstract

“Athran” field is an active field for hydrocarbon exploration with trending northeast-southwest and focus on the reservoir zone is the Talang Akar Formation with A-C layer intervals. The method used in this research is electrofacies, delta deposition system, formation evaluation, static reservoir modeling, and multi-attribute linear regression. The distribution of reservoir modeling is done by using the stochastic variogram method to make modeling lithofacies and depositional facies. Identification of lithofacies in the study area obtained two units, namely sandstone and shale facies. The depositional facies analysis was carried out using the electrofacies approach, showing that the research target was in a transitional environment with a delta deposition system, namely the distributary channel, delta front and prodelta. The deposition process. Sandstones and shales affect the distribution of porosity which functions as a reservoir property. The data integration of the distribution of lithofacies, gamma ray and porosity was carried out using the multi-attribute linear regression method to predict data both vertically and horizontally. The results of this study are used to help determine the distribution direction and direction of sediment deposition as a good reservoir zone for exploration activities.

1. Introduction

The biggest challenge in oil & gas companies is to find the right reservoir in a formation in an exploration field, especially if the target formation used as the research area has a very thin layer character. This happened in the author's research area in the Talang Akar Formation in the "Athran" Field of the South Sumatra Basin. Therefore, to determine the best seismic method to identify the A-C target reservoir layer in this formation, the researchers used a combination of static reservoir modeling methods and multi-attribute methods to identify the distribution of the predicted values for reservoir porosity and lithology. The problem that exists because it cannot separate the acoustic impedance value between sandstones and shales, the authors carry out the multi-attribute seismic linear regression method.

2. Methodology and Result

2.1. Static reservoir modelling

Static reservoir modelling can be done in two ways, namely, simulation and determination. Static reservoir modeling is done by means of determination, namely reservoir modeling using geostatistical methods. This method was chosen because of the limited well data, so it must be done with a statistical approach. Geostatistics uses the correlation function to quantify the spatial relationship, and the variogram is one of the correlation functions in geostatistics applied in this research and is the method most commonly used in describing patterns of spatial relationships between data and quantifying spatial variations of spatial phenomena that occur. The variogram shows how far a parameter will affect the estimated value or the difference with the distance [1]. Analysis of this variogram model works based on the pattern of linkages between data so that data can be estimated based on data that still influence each other. The variogram has main parameters, namely sill, range, and nugget. The range parameter is the distance between the points when the sill is reached, or in other words, the distance until it reaches

points that no longer have spatial dependence. Sill is the maximum difference value or constant variogram value after the range is reached. The nuggets show variations at the point that cannot be explained spatially [1].

There are three directional components used to explain the relationship between data in variogram analysis, namely major, minor and vertical directions. The major direction shows the longest distance representing the horizontal plane and serves to predict the lateral distribution of data according to the interpretation of the reservoir interval sedimentation direction. The minor direction represents the horizontal direction perpendicular to the major direction. The minor direction interpolates the data assuming the width of the reservoir type sedimentation. The vertical direction represents the vertical plane and functions to estimate the data relationship of reservoir thickness or thickness of each reservoir composing deposit [2]. The following can be seen from each component in the variogram analysis.

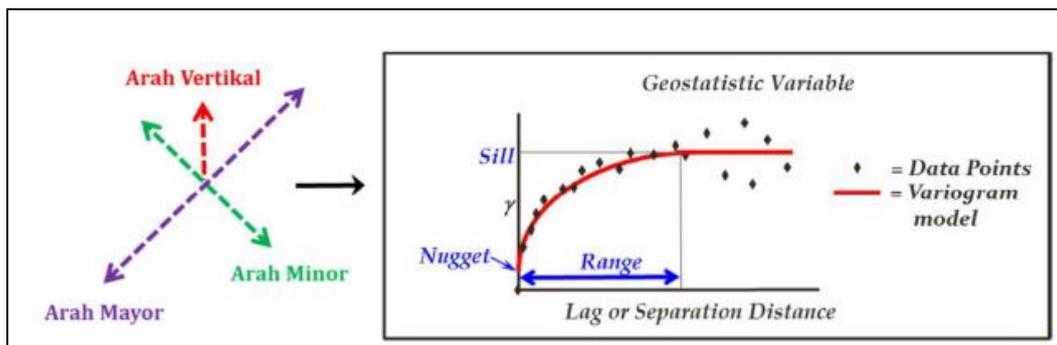


Figure 1. Parameters component in Variogram Analysis (modified [2]).

2.2. Seismic multi-attribute method

Seismic Multiattribute is a statistical method using more than one attribute to predict some physical properties of the earth. [3] identified three main sub-categories of multi-attribute geostatistical analysis techniques, namely:

- Extension of co-kriging to involve more than one secondary attribute to predict the primary parameter.
- A method that uses a covariance matrix to predict a parameter of the input attribute that has been linearly weighted.
- Methods that use Artificial Neural Networks (AANs) or non-linear optimization techniques to combine attributes to estimate the desired parameters.

Multi-attribute analysis in this study uses the second category. The process itself involves the creation of a volume pseudologist which will later be used to map the distribution of sandstones and claystone [4]. In the most common case we are looking for a function that will convert m different attributes into the desired property, this can be written as follows:

$$P(x,y,z)=F [A_1 (x,y,z),\dots,A_m (x,y,z)] \dots\dots\dots(1)$$

where: P : log property, as a function of the x, y, z coordinates. F : states the relationship between the seismic attribute and the property log. A_i : attribute m , where $i = 1, \dots, m$.

For the simplest case, the relationship between log properties and seismic attributes can be shown by the linear weighted sum equation as follows:

$$P=W_0+W_1 A_1+\dots+W_m A_m \dots\dots\dots(2)$$

with: W_1 : The weight value of $m + 1$, where $i = 0, \dots, m$.

Then how do you choose the best combination of attributes to predict the target log? A process called step-wise regression is carried out:

- Look for the best single attribute first by using trial and error. For each attribute contained in the software, the prediction error is calculated. The best attribute is the attribute that gives the lowest prediction error. This attribute will then be called attribute-a.
- We look for the best pair of attributes by assuming the first pair of members is attribute-a. The best pair is the partner who gives the smallest error. This attribute will then be called attribute-b.
- We look for the three best paired attributes, assuming the first two members are attribute-a and attribute-b. The three best attributes give the smallest prediction error.

This prediction continues as much as desired. The prediction error, E_n , for n attributes is always less than or equal to E_{n-1} for $n-1$ attributes, no matter which attribute is used. To measure the validity of the number of attributes used, the following procedure is performed. For example, there are three attributes and five wells. For the first calculation, the first well will not be included. Then the regression coefficient is calculated, without using data from the first well. With the resulting coefficient value, the predicted error from the well is calculated [4]. The multi-attribute analysis described above correlates each target sample with the attribute seismic sample at the same point. This approach is very limited because it ignores the fact that there is a difference in frequency content between seismic data and log data.

2.3. Facies analysis

Based on the analysis of the electrofacies method [5] and the depositional environment model [6] [7], the results of the well correlation GPS-14, GPS-6, GPS-1, and GPS-20 have three types of depositional facies, namely the distributary channel, delta front (distributary mouth bar) and prodelta, this is part of the transitional environment with delta deposition system.

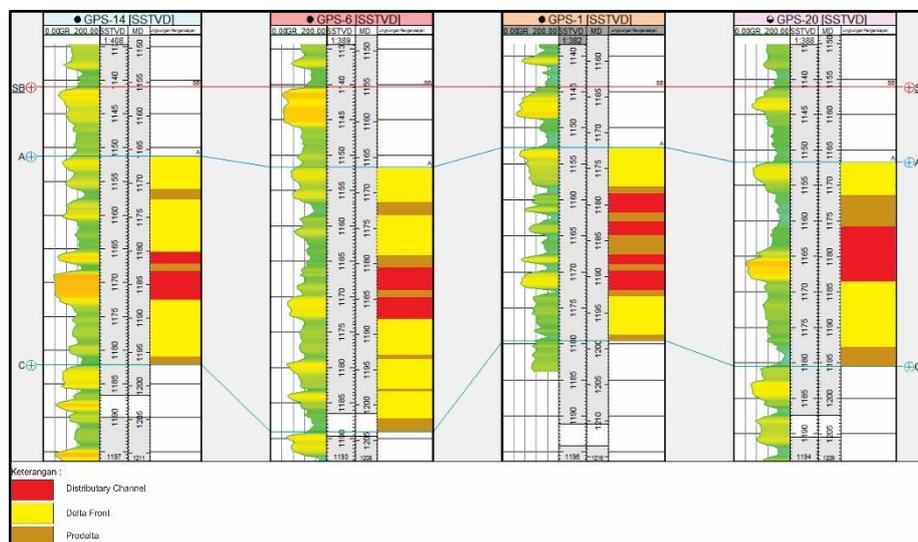


Figure 2. Facies interpretation of the depositional environment

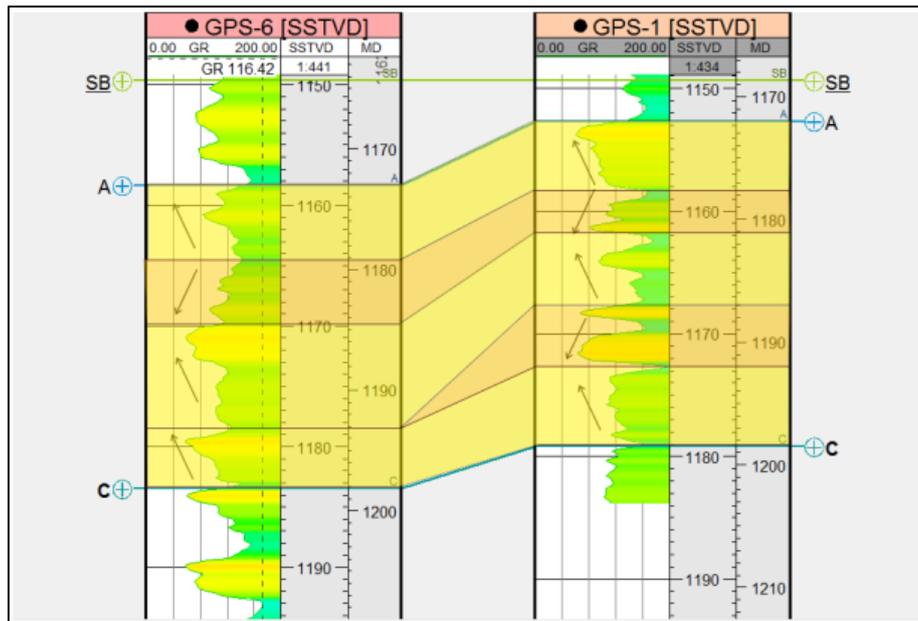


Figure 3. Correlation between GPS-1 and GPS-6 well depositional facies.

In general, the above correlation can be concluded that the higher it is, the shale content will dominate. It can be assumed that the transgression phase is increasingly dominating so that the deposited material will become a fine material. Likewise, facies extension and lithology towards the southwest show the same thing, although there is still sand intersection in the southwest area, this lithology is not so dominant. Based on the above correlation results, the researcher can conclude that the research area is a delta deposition system process in a transitional environment, as well as the direction of deposition with a northeast-southwest trending.

2.4. Variogram analysis

This variogram process is done by first scaling up the well log, this process aims to spread the data vertically [1]. The trick is to determine the value in the cell or grid from the average value of the reservoir properties that have been calculated using the formation evaluation method. One of the examples of scale-up well log is the GPS-24 well.

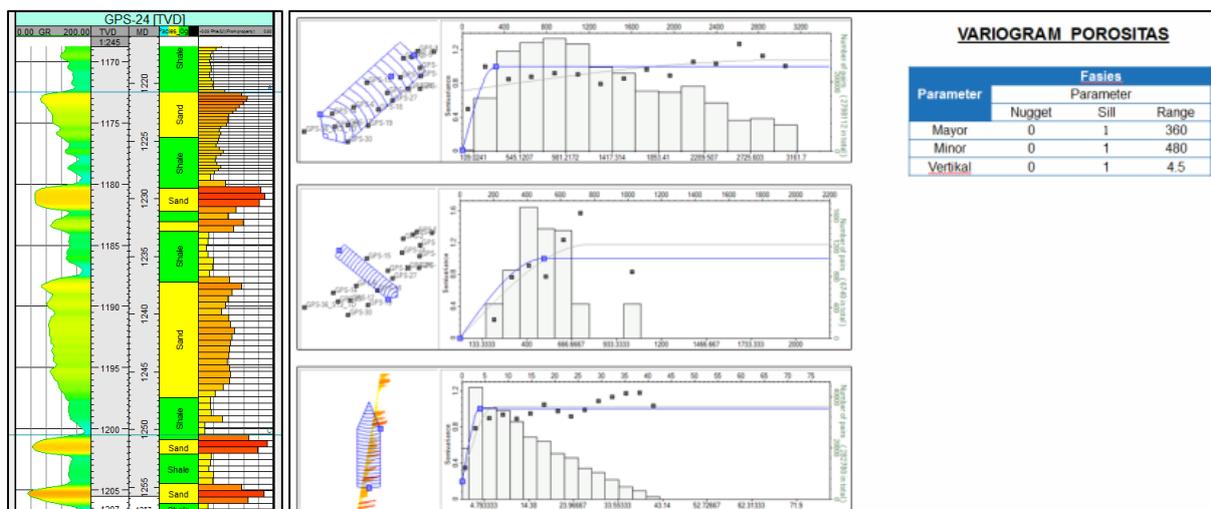


Figure 4. The results of the scale-up well log analysis on the GPS-24 well (left), **Figure 5.** Analysis of Facies variogram on the GPS-24 well (right).

After determining the variogram, it can be seen that the direction of sedimentation (major) is northeast-southwest. This is consistent with the results of previous stratigraphic correlations. After the variogram analysis was carried out, based on these data, facies and porosity modeling was made.

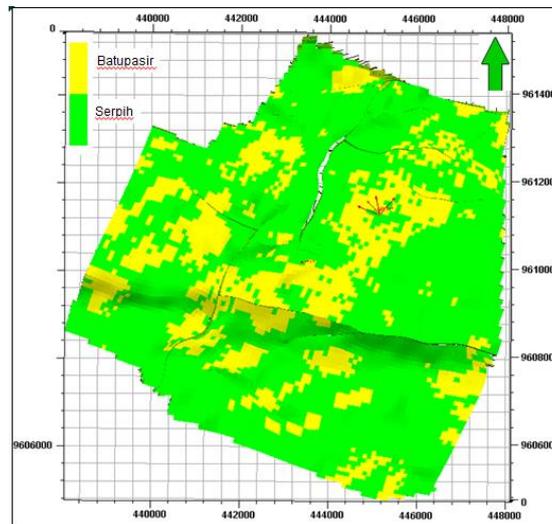


Figure 6. The model of lithofacies

2.5. Head loss calculation

Before carrying out the well seismic tie process, it is necessary to correct the sonic log data using the checkshot data. In this study, the ricker wavelet uses a minimum phase with a dominant frequency of 15 Hz and a wavelength of 100 m [8].

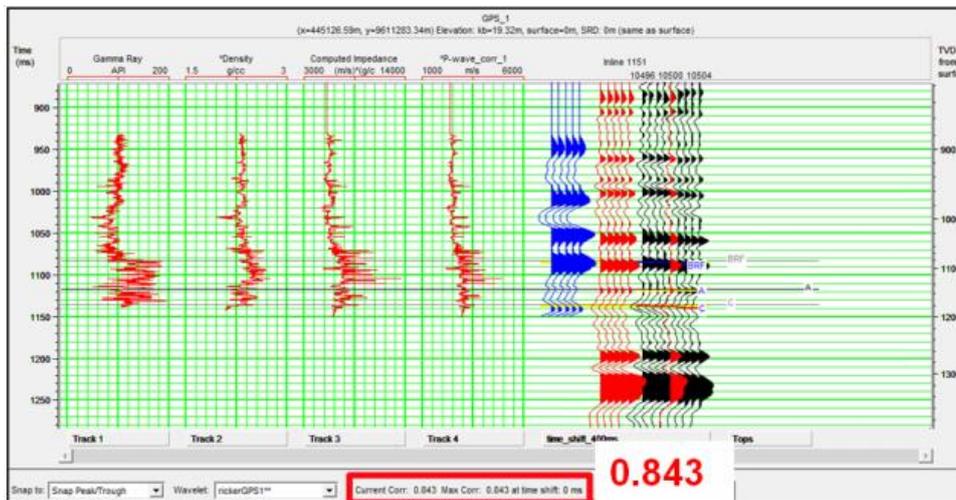


Figure 7. Well tie of GPS-1

2.6. Head loss calculation

Crossplot analysis is intended to see the separation of types of lithology. From this crossplot analysis, it can be seen the values of physical parameters, both quantitatively and qualitatively, so that they can be used to determine the cut-off value. The gamma-ray cut off value between sandstones and shales in GPS-1 is <100 gapi. while values > 100 gapi are flakes. Whereas in GPS-6 well, the cut off value of gamma-ray is around <113 gapi for sandstones and > 113 gapi for shale. It can be seen from the crossplot results above that the acoustic impedance values of the two lithologies cannot be separated. This is what makes this study choose a multi-attribute method to predict or estimate the volume of the log property [8].

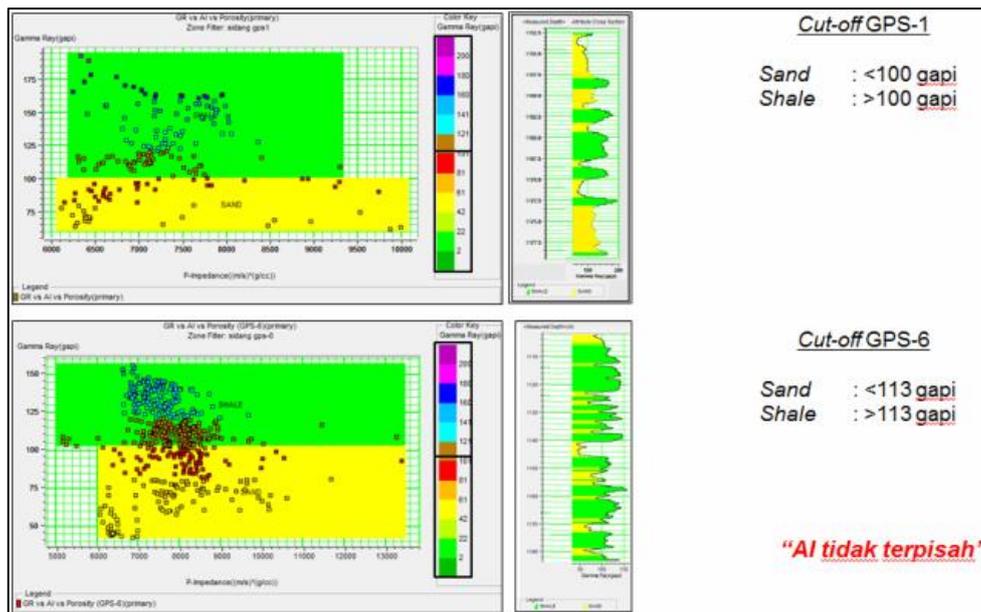


Figure 8. Crossplot log P-impedance vs log gamma-ray on well GPS-1 and GPS-6

2.7. Multi-attribute analysis

The purpose of this process is to predict the distribution of the sandstone reservoir using gamma-ray log predictions and porosity [4]. The multi-attribute process input data used 3D PSTM seismic data. In the multi-attribute seismic analysis, linear equation (linear regression) is used. The purpose of using this analysis is to improve the prediction results so that they are closer to the actual data. From the training results, it was found that the value of validation for errors and prediction of errors decreased until the use of five attributes. Using more than five attributes in this case will cause the data to be overtraining. This is shown by the error validation value that increases after the use of the five attributes.

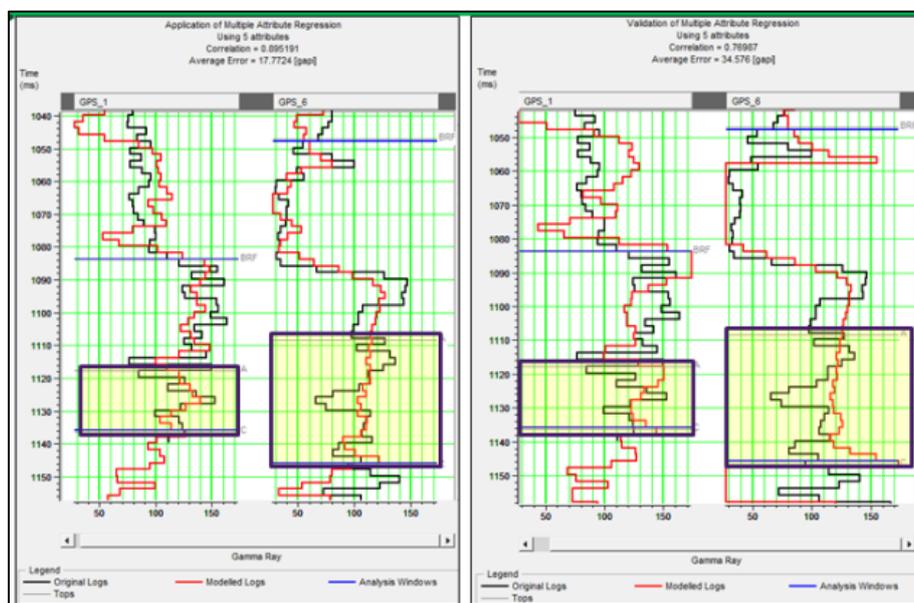


Figure 9. Training and validation error of log gamma-ray

3. Result

After the multi-attribute was applied, the results of the gamma-ray log prediction on the seismic data around the well location showed a correlation value of 0.895191 when the crossplot was carried out to the actual gamma-ray value in the well. These results indicate that the results of the gamma-ray prediction using these five attributes are quite good [9].

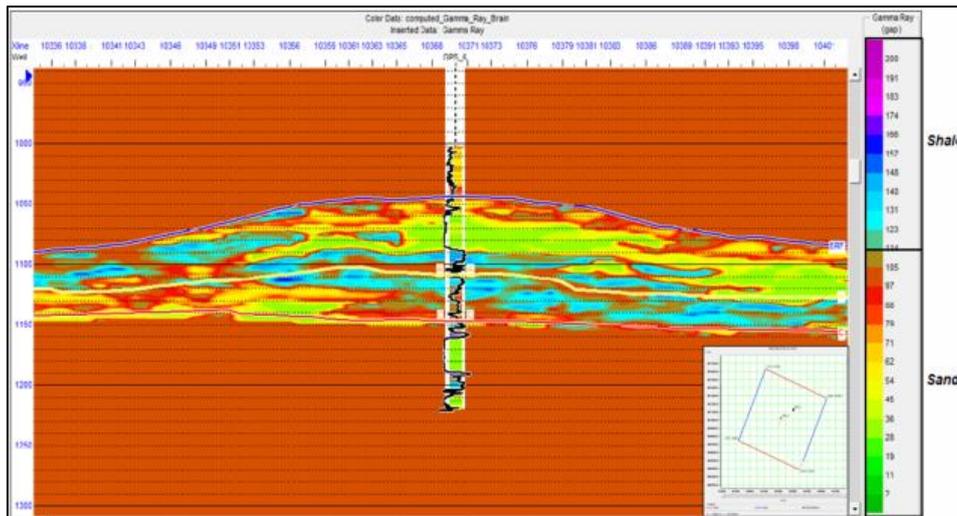


Figure 10. Pseudo Gamma Ray

3.1. Pseudo Gammar Ray volume prediction analysis

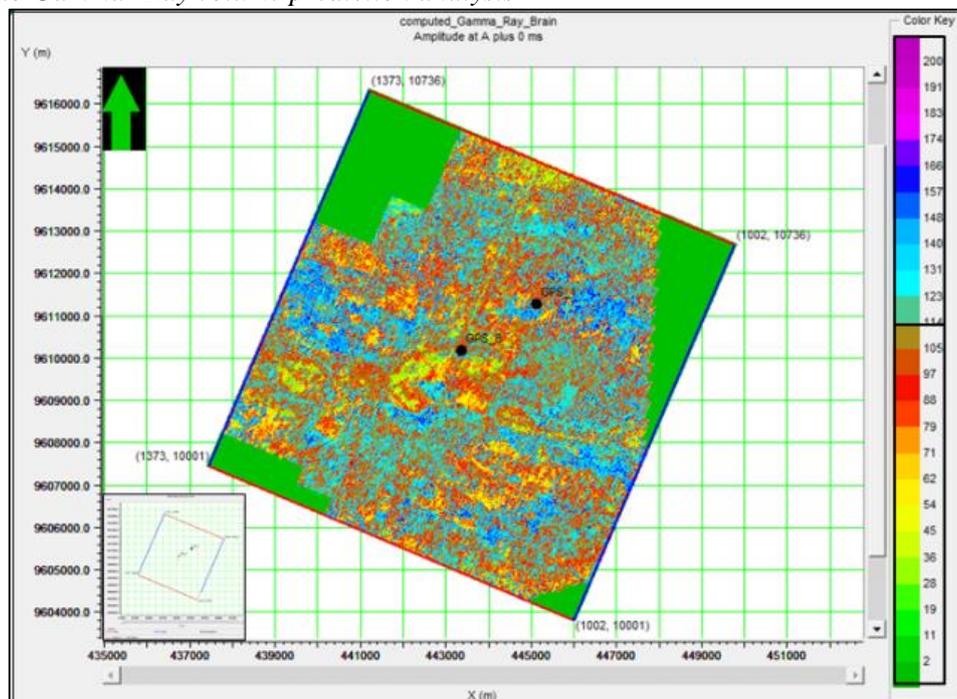


Figure 11. Slice map of gamma-ray distribution on layer A

From the gamma-ray distribution cross-section (Figure 14), there is a good match between the predicted gamma-ray and the well's gamma-ray. The results of training and validation also show a fairly good correlation and validation. The correlation value is 0.895191, which means that the predictive gamma-ray is close to the gamma-ray value of the well. On this basis, it is assumed that the resulting gamma-ray volume is valid for predicting reservoir distribution and can be expected to separate the sandstone and shale lithology in the research target area.

After knowing the estimated lithofacies boundary), then predicting the limit of gamma-ray distribution which is expected to provide information about the boundary between the distribution of sandstone and shale reservoirs in the Talang Akar Formation [9]. After the cut-off analysis was carried out, it was found that the average range of gamma-ray cut-off values was in the range <113 gapi is sandstone (yellow-green in the study area) and > 113 gapi is shale (blue-purple in the study area). After comparing with the results of the distribution map of the lithofacies model, it turns out that the pattern of the

lithofacies distribution of sandstones (yellow color) is at the same interval and position as the gamma-ray distribution in the cut-off range <113 gapi.

4. Discussion

Based on the results of data analysis and processing, it can be concluded that from the results of facies interpretation based on well log data, here are two kinds of lithofacies in the research target, sandstones, and shales. The facies deposition of the research area occurs in a transitional environment with a delta deposition system. There are three facies of delta deposition are distributary channel, delta front, and prodelta facies, the facies change was caused by the tectonic movement between the Eurasian plate and Hindi-Australian plate [10][11][12]. The stratigraphic correlation shows a pattern of sandstone distribution increasingly thickened towards the southwest. This can be a sign that it is supply sediment in the research area trending northeast-southwest. Evaluation of the interpretation of the gamma-ray log shows that the shale content is getting upward, the more dominant it is developing, so it can be concluded that the Talang Akar Formation occurs a transgression phase. The results of the variogram analysis support the trend of the northeast-southwest data distribution. The use of multi-attribute can help ensure the prediction results based on linear regression calculations. The result of multi-attribute linear regression on the prediction of pseudo gamma-ray has a correlation of 0.895191 with an error of 17.7724 gapi.

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