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Seismic Interpretation and Reservoir Static Model: A Case Study in Block MFK, Riau Province, Indonesia

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Abstract. MFK Block was located between Kampar and Rokan Hulu, Riau Province and 135 from Pekanbaru City, Indonesia. There are 33 wells in Field X, MFK Block with 27 active wells. This field has an area of about 79.65 km² that located in Central Sumatra Basin. The field was discovered in 1976 and began to be produced in January 1979. Our research is focused on AK reservoir intervals, which is also part of Bekasap formation. The main aims of this study are to interpret field structure model, determine the distribution of reservoir properties, develop static reservoir model for field as a reference for field performance enhancement, estimate oil reserves in the field reservoir, and the prospect of hydrocarbons in the AK reservoir. The available data are 2D seismic data, mudlog descriptions, well log data, and perforation data. The methods used in this study are stratigraphic sequences, electrofacies analysis, geological structure analysis, static reservoir modelling, and estimation of hydrocarbon reserve volumes. Based on mudlog and electrofacies analysis, the study interval was arranged into 2 lithofacies units, namely sand channel and sand bar. The depostion environment of Bekasap Formation is estuarine environments. The interval of the study has an association of fasies moving northeast to southwest. Based on the results of property reservoir analysis, facies that have good reservoir quality is sand channel facies. Based on the static modeling method approach, the estimated stock tank oil initially in place (STOIIP) for AK reservoir interval is 728 MBBL.

1. Introduction

Reservoir geological modeling plays an increasingly important role in determining distribution, depth configuration, and reservoir quality [1]. The construction of the reserbor model is a common model for geological horizons and faults that form geometric frames from three-dimensional grids and form boundaries of facies and petrophysical models representing the properties of rock [2]. The research field (Field X) has an area of about 79.65 km² located in Lembangan Central Sumatra. The field was discovered in 1976 and began to be produced in January 1979. This field reservoir is included in the formation of Bekasap with lithology that constituents are in the form of sandstone with glauconite content at the top and shale inserts, thin limestone and thin layers of coal with a depth of 1200 - 1300 feet. Geographically, the research field is located on the MFK block between Kampar and Rokan Hulu Regency, Riau Province. So far there are 33 wells in Field X, MFK Block with 27 active wells.

Several recent studies of resrvoir static model in this area. In 2018, volumetric calculations are carried out using the water contact boundary with the degraded hydrocarbons and obtained hydrocarbon volume in this field with a total of more than 34 million barrels [3]. This field located 135 kilometers from Pekanbaru City (Figure 1).

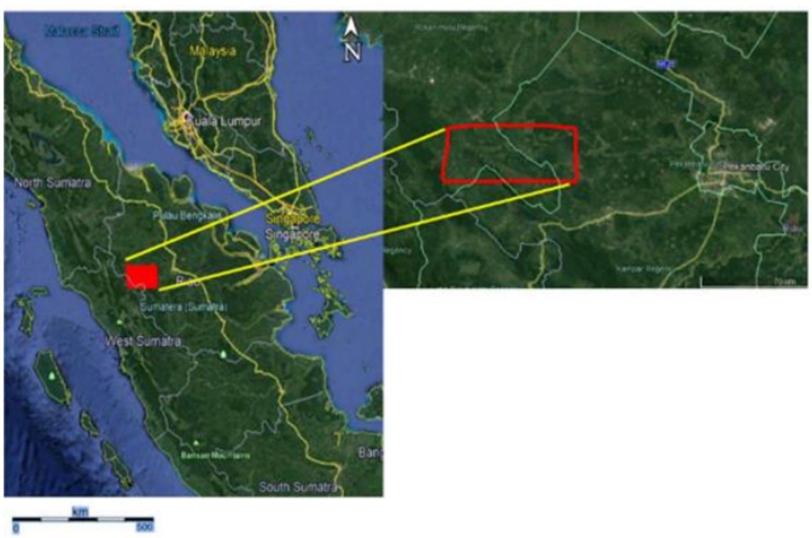

Figure 1. The goggle earth view of the study field

The objectives of this paper are (i) Interpreting field of the structure model and distribution of reservoir properties, (ii) Develop a static model of reservoir for field as a reference for improved field performance and (iii) Estimating oil reserves in reservoirs on field. The research will focus on the construction of static models in the field as well as the distribution of fasies and distribution of reservoir properties. At the end of this study, it will be determined which areas have the potential for future field development.

2. Geological Setting of the Study Area

The Field X is one of the oil fields located between Kampar regency and Rokan Hulu, Riau Province, Central Sumatra' Lembangan (Figure 2). The Central Sumatran Development is a back arc that develops along the edge of the Sunda Stage in southwest Southeast Asia [4]. The southwestern part of Central Sumatra's Lembangan is bounded by Bukit Barisan, while the northwestern part is bounded by the Tigapuluh High court and the northeastern part is also bounded by the Sunda Palace.

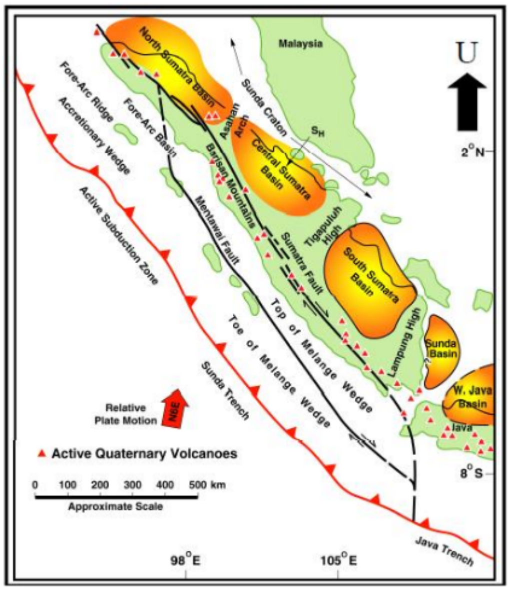

Figure 2. The location of the study area.

The tectonics of the Central Sumatra Balance are characterized by fault blocks and front faults, such as as asecension, gravity tectonics, windings and compressed folds. The system of fault blocks has a North-South alignment orientation to form a series of horst and graben. There are two main structural patterns in this development, namely the old pattern that tends to the North-South while the younger pattern also tends towards the Northwest-Southeast [5].

3. Material and Methods

In this study, to produce a static model of the reservoir, well data processing consisting of mudlog analysis, stratigraphic sequence analysis, electrofasies analysis that can determine the deposition environment of the research area as modeling inputs. For seismic data processing, the binding of well data with seismic is done first before picking faults and picking horizons. Using Petrel software, the distribution of fasies and the distribution of petrophysical properties from the reservoir. Figure 3 shows the flow of work in this study.

3.1 Determination of Deposition Environment

The analyses used for the determination of the deposition environment are mudlog analysis, stratigraphic siquence analysis and electrofasies analysis. External data such as mudlog data (data from sludge used for drilling) are required to strengthen fasies analysis [6]. Stratigraphic sequence analysis is an attempt to connect the correlative sequence and aligned (there are no misalignments in between) despite their different lithologies or constituent facies. The interpretation of electrofasies refers to the gamma ray log pattern reaction (GR) model proposed by [7]. Gamma log responses to variations in detailed measurements characterize sedimentary relationships in certain deposition environments [7]. By integrating data from mudlog data, lithology, jujukan, stratigraphy and electrofasies will be obtained certain deposition environments in the research area.

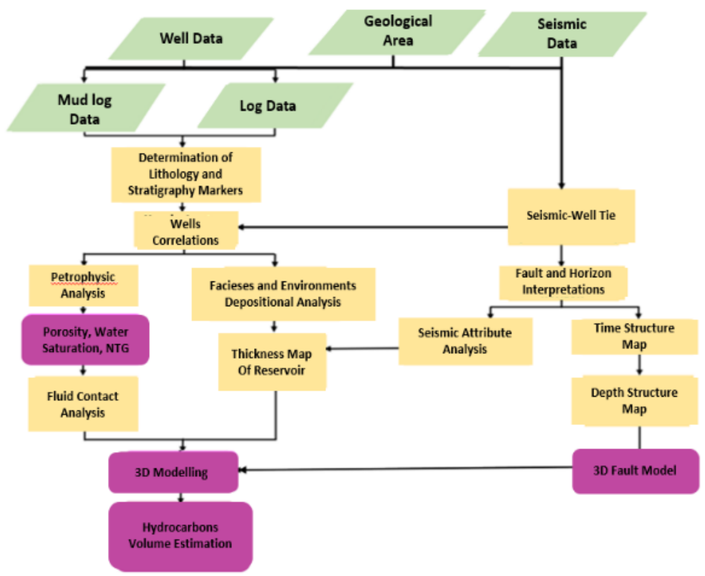

Figure 3. Research Workflow for this study

3.2 Petrophysics Analysis

Petrophysics analysis is performed to determine reservoir properties by analyzing vshale values, effective porosity, and water saturation. Vshale analysis is used to calculate layers that have shale inserts that can affect the results of the analysis of porosity and saturation of water using equations:

$$Vsh = \frac{(GR\ read - GR\ min)}{(GR\max - GR\min)} \quad (1)$$

Where,
Vsh = volume of shale (%)
GR read = reading of gamma ray values on logs (GAPI)
GR max = maximum gamma ray value (shale)(GAPI)
GR min = minimum gamma ray value (sand)(GAPI)

Determination of porosity is done using the Bateman-Konen equation where density log (DPHI) and neutron log (NPHI) data as raw data. With a formula for determining porosity [8] :

$$øN = \sqrt{(øN^2 + øD^2) \div 2} \quad (2)$$

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Where,
$ø_N$ =neutron porosity
$ø_D$ =density-porosity
$ø_{ND}$ = neutron-density porosity (Bateman-Konen)

Water saturation is the ratio of the contents of stone pores filled with the number of pores in porous rocks. In the water saturation ratio, water attached to the shale surface is not included in the calculation. Therefore, it is necessary to correct the volume of the scarf before calculating the saturation of water. Water saturation plays an important role in petrophysical analysis because it can determine hydrocarbon saturation. The general formula used using equations [8] is as follows:

$$Sw = \frac{(a \; X \; Rw)}{(øn \; X \; Rt)} N^{-1} X \; 100\% \tag{3}$$

Where,
Sw = water saturation (%)
a = turtosity factor
m = cementation factor
n = Exponent of saturation

3.3 Seismic Analysis
Identification of geological features such as large and small faults is carried out on seismic parts. Well tie to Seismic is done using AK-1, AK-2 and AK-6 well data and checkshot surveys fromAk-1 to produce a synthetic seismogram, hence, tying the seismic to wells (Figure4).

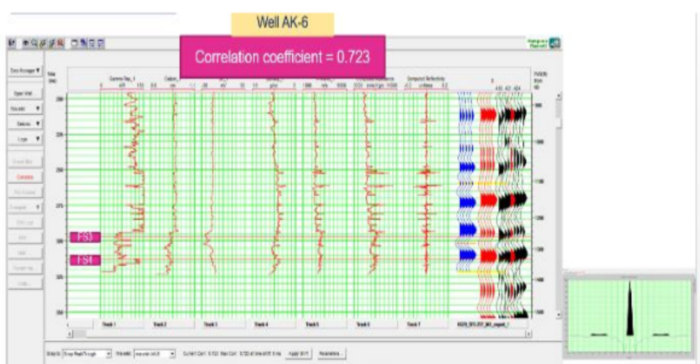

Figure 4. Seismic Well Tie

From seismic data obtained faults that are northwest-southeast after picking faults. Picking horizons are carried out at intervals of research areas with the final result being a map of the depth structure.

3.4 Volumetric Calculation
Reservoir volume is a process by which the quantity of hydrocarbons in the reservoir is estimated. This is very important because it serves as a guide for field exploration and expansion. Once the field static model is completed, the built petrophysical structure and model model is used to calculate the reserve in terms of on-site oil stock tank (STOOIP) Field X, estimated using the equation:

$$STOIIP \; (STB) = 7758 \; X \; A \; X \; h \; X \; \Phi \; X \; (1 - Sw) X \; \frac{1}{Bo} \tag{4}$$

Where,
A = An acre area, Acre-foot
H = feet thickness clean in foot unit
Φ = porosity
S_w = water saturation
B_0 = Formation Volume Factor

4. Results

There are 3 scopes of work carried out on this study which are included well data analysis, seismic data analysis and the creation of a 3D static model framework.

4.1 Well Data Analysis

The first stage carried out in the work of this study is mudlog analysis where two litofasies codes are obtained from mudlog descriptions namely smc (medium to coarse sand) and svftm (very fine to medium sand) (Figure 5). Based on the analysis of stratigraphic elbows on wells in the research field, 2 dominant track systems, namely lowstand system track and highstand stystem track were identified. The direction of the estuarine channel form on the correlation of stratigraphic sequence are north-south (Figure 6). In the field of research there are two dominant types of logs, namely funnel shape and cylindrical shape that shows this area is deposited in the environment of sand bar and channel sand. By integrating data from the analysis of cutting mudlog, lithology, stratigraphy sequence and electrofasies, it can be concluded that the research interval is deposited in the lower Estuarine or Marine Energy Dominated Estuarine environment with the sub-deposition environment, the Estuarine Channel.

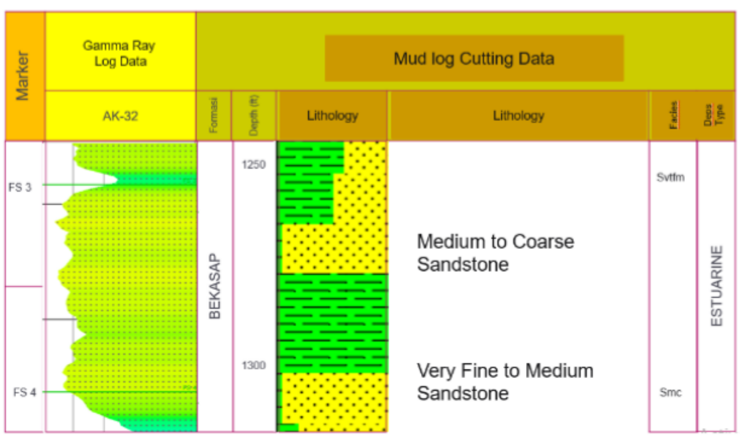

Figure 5. Mudlog Analysis

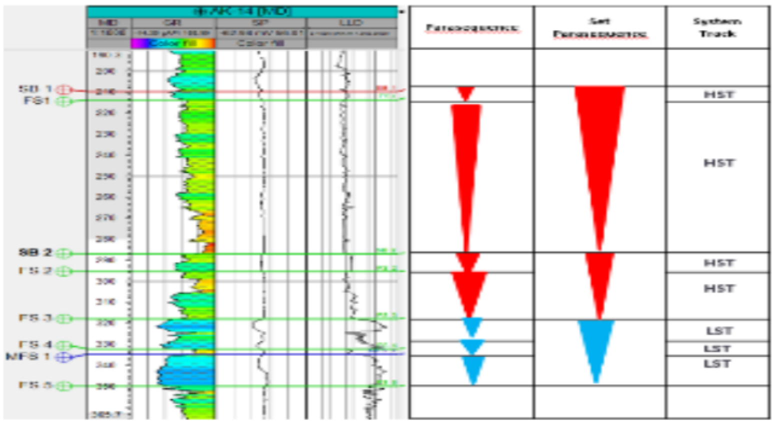

Figure 6. Stratigraphic Sequence Analysis

4.2 Seismic Data Analysis

Seismic data analysis begins with the seismic-well tie which is compressed by a good correlation coefficient value of 0.723. After that, a picking fault is carried out in the research area which is then continued with a picking horizon that produces a map of the time structure. Data conversion over time to depth is done for analysis of modeling data in the depth domain. Figure 7 shows the results of the creation of a map of the depth structure.

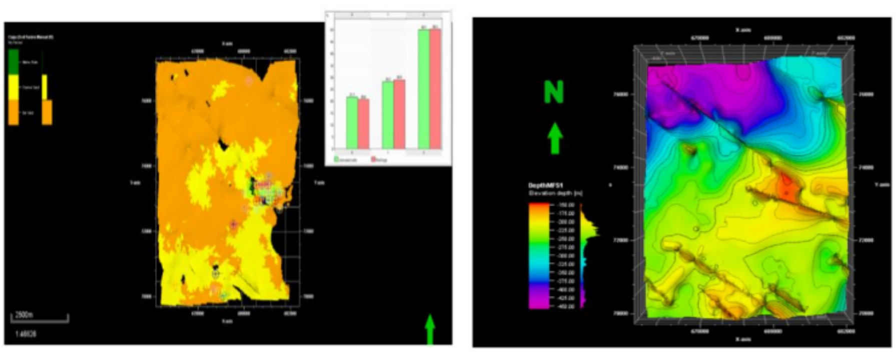

Figure 7. Depth Structure Map

4.3 3D Static Modeling

The static modeling process of the reservoir begins by making a fault model resulting from seismic interpretation which then continues with the creation of 3D pillar gridding (Figure 8). Then the creation of layer and zone models as a modeling reference.

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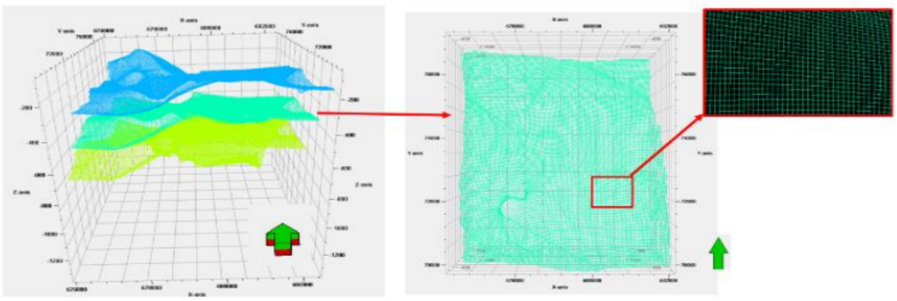

Figure 8. Pillar Gridding

The process of scale up well log is carried out for the alignment of well log values vertically in each cell by entering well analysis data into the 3D grid model.Figure 9 shows the results of scale up well log.

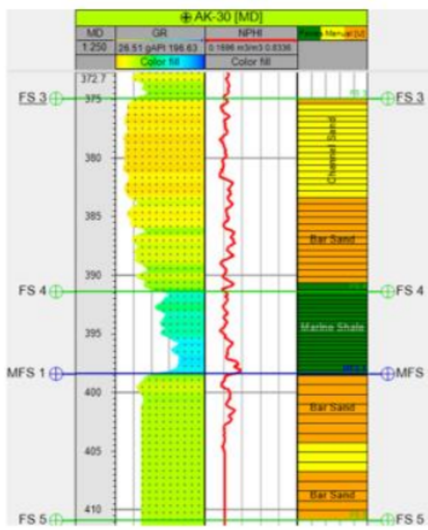

Figure 9. Log upscalling result at Well AK-30

The process of modeling fasies is done using sequential indicator simulation methods. Avariogram analysis on data analysis is also used to disseminate data at a certain distance so that there is no change in value (Figure 10).

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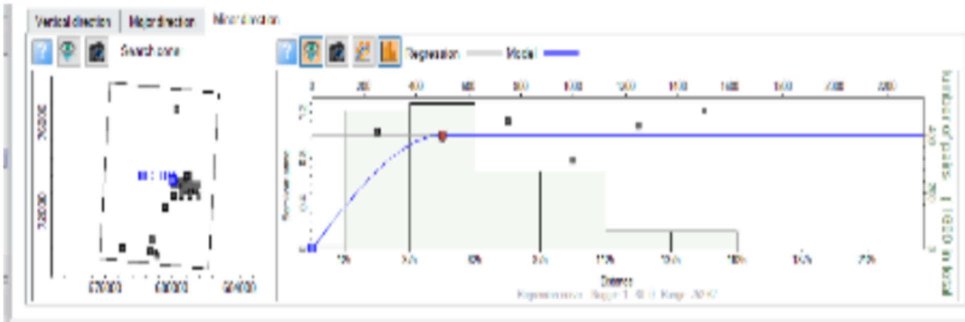

Figure 10. Facies Modelling and Variogram Analysis

Petrophysical property modeling includes Vshale modeling, porosity and water saturation. Porosity logs and SW logs that have been scaled up become basic inputs in reservoir modeling. Variogram analysis on analytical data is also used to disseminate petrophysical property data. Figure 11 shows the results of petrophysical property modeling

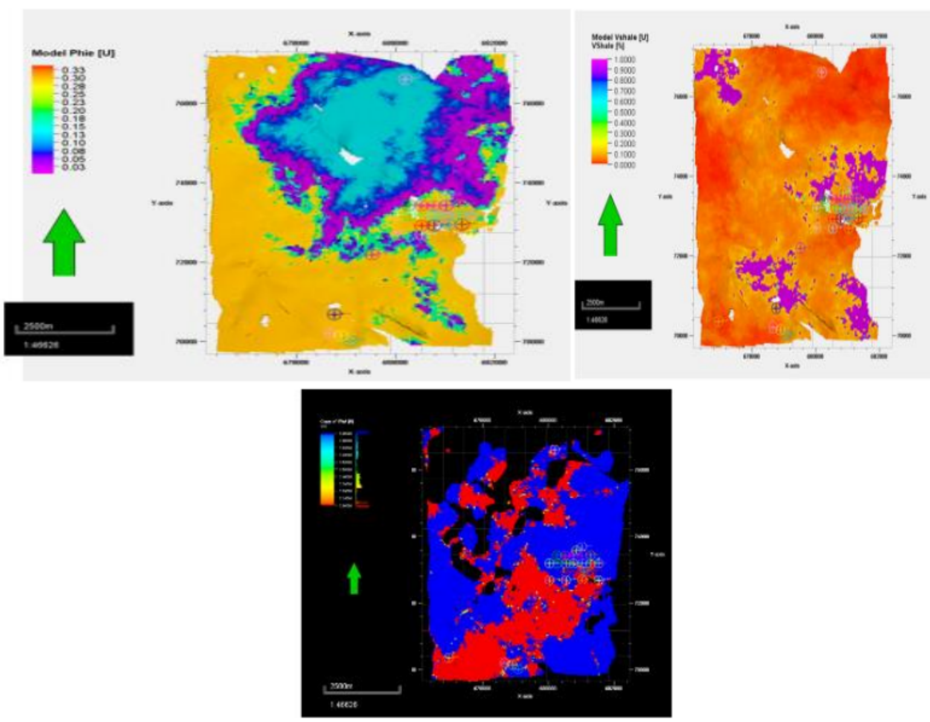

Figure 11. Petrophysical Property Modeling

4.4 Volumetric Calculation

Table 1 reveals volumetrics after modeling. It was found that the Stock Tank Original Oil in Place (STOOIP) at the research interval is amounted to 728 MSTB.

Table 1. Volumetric Calculation

Interval Research	BV (acre. ft)	PV (acre. ft)	STOOIP (MSTB)
Reservoir 1.1	529	423	296
Reservoir 1.2	949	760	532
Total	1478	1183	728

5. Discussion

Determination of the deposition environment is required for static modeling data input. From the analysis of mudlog data, stratigraphic sequence and electrofasies analysis found that the research area is deposited in the estuarine channel environment.

A depth structure contour map shows a fault growth system oriented toward the Northwest- Southeast that is interpreted as a fault formed in late Neogen.

The static modeling process begins with a fault model resulting from seismic interpretation which then continues with the creation of a 3D pillar gridding consisting of cells at the top, middle, and bottom. This pillar gridding will be the basis of the spread of the reservoir property. Then the creation of horizon modeling results from the interpretation of layers in seismic.The next stage is to create zoning with well marker input from log analysis. The last process is layering model, the thickness of this layer will be affected by the thickness of facies. In the stages of reservoir modeling there are four processes, namely scale up well log, fasies modeling, Vshale modeling, porosity modeling and water saturation modeling. Validation of the results of scale up well logs is done by looking at the difference between the histogram of log data and the results of scale ups.Fasies modeling is done using the Sequential Indicator Simulation deployment method where the variogram analysis is used as a controller of the spread, so that at a certain distance there is no change in value with vertical, major, and minor axis orientation.Reservoir property modeling is closely related to STOOIP calculations. Porosity logs and SW logs that have been scaled up become basic inputs in reservoir modeling. Variogram analysis on analytical data is also used to disseminate reservoir property data.The process of porosity modeling is controlled by the fasies model and SW modeling is controlled by the porosity model. Spreading properties using the Sequential Gaussian Simulation deployment method.This method is chosen because the properties of the reserbor are continuous variables so that they are suitable for use in the SGS method.The distribution of reservoir properties from 3D static modeling shows that the resevoir distribution follows the direction of the facies association which is in the northeast-southwest and the next development direction is in the southeastern part of the model.

All variables in hydrocarbon volume equations have been obtained from previous data analysis. The calculation result will be obtained in bulk (acre.ft) which is the total number of zones restricted by fluid contacts. In addition, the clean volume (acre.ft) is the volume of the area above the touch of fluid. The next calculation is STOIIP or stock tank initial oil in place by dividing between the value of HCPV and the formation factor.Stoiip was generated at research intervals of 728 MSTB.

6. Conclusions

3D static modeling begins with cesarean modeling. Rather than fault modeling, the fault resulted in a dominant fault toward the Northwest – Southeast which was interpreted as a fault that formed in the late neogene period. The sprinkling of reserbor properties from 3D static modeling shows that the reservoir sprinkles follow the direction of the fasies association, which is in the northeast-southwest and the next direction of expansion is in the southeastern part of the model. Based on the calculation of hydrocarbon reserves using the volumetric method, the research area has an estimated total hydrocarbon storage (STOIIP) of 728 MBBl, with details for the reservoir zone 1.1 of 296 MSTB, and a reservoir zone of 1.2 of 532 MSTB. The calculation of the amount of hydrocarbons per horizon will differ due to the fluid contact factor**.**

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