STOCHASTIC POROSITY MODELING IN VOLCANIC RESERVOIR JATIBARANG FORMATION

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Abstract. Jatibarang Formation known as interesting volcanic reservoir in North West Java Basin. The reservoir was characterized by altered and naturally fractured that has significantly producing light oil. The volcanic Jatibarang reservoir consist of 3 volcanic cycles that are cycle 1, cycle 2 and cycle 3 with 16 faults configuration. Total and Fracture porosity modeling was conducted to determine secondary porosity distribution using stochastic method. Lithofacies and property lateral variation were generated to visualize geological model. Total porosity was estimated using formation evaluation. Natural subsurface fracture has been identified by bore hole image (formation micro imager) and geophysical log from several wells in the Jatibarang Field. It has provided both lithology and property reservoir information. Lithofacies tuff and non tuff model has been used as a constrain to distribute pore pressure and bulk modulus. Then, porosity model was distribution using the collocated-co kriging method. The purpose of this study was to determine the distribution of total and fracture porosity of the Jatibarang volcanic reservoir.

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INTRODUCTION

Recently, two main groups of geostatistical techniques have been adopted to construct numerical models of petrophysical properties (Sahin and Salem, 2001). Modelling refers to the process and then generating simplified representation of a actual condition. Geostatistical methods can be divided into deterministic and stochastic method. Deterministic model is a mathematical model which contains no
random components. Stochastic model is a mathematical model that includes some sort of random forcing. In deterministic analysis can only offer one solution because deterministic result can be unambiguously described by the completely known condition (Zelenica et al, 2017). Mathematics applied is required within deterministic and stochastic modeling. Stochastic approaches have recently been to calculated reserve volume based on geological data. The important factor to stochastic geological modeling is considering parameter correlation within our geological understanding (Wellman et al, 2014).

In many cases, stochastic models are used to simulate deterministic systems that include a phenomenon that can not be accurately modeled. Stochastic model are described by random variables that yields a manifold of equally likely solutions and allow the modeler to evaluate the uncertainty (Renard et al, 2013). Basically, stochastic modelling assumes that the unknown parameters have been generated by randomness mechanism. To adopted numerical reservoir models such as porosity required stochastic simulation techniques (Sahin and Salem, 2001). The kriging method is a mathematical interpolation which estimate variable value in the grid (Matheron, 1965). The Sequential Gaussian Simulation (SGS) is one of the popular conditional simulation techniques employed in reservoir characterization. The SGS algorithm provides a simulated value at any location by first determining the probability distribution at that location, and then drawing a number at random from this distribution. To calculate and estimating fracture porosity, wireline log and image log (FMI) data are needed. Information on the FMI (Fullbor Formation Micro-Imaginer) needed to calculate fracture porosity such as the fracture length, area, and aperture. The main strength of the reservoir is limited by dipmeter and constraint BHI reservoir model is a merging of direction information in the wellbore that can represent subsesismic properties and provide local calibration for seismic attribute (Pöppelreiter, Crookbain, Sapru, & Lawrence, 2010). The model used in estimating fracture porosity in this study is the HALO model, which reveals the concept of the damage zone of the fault plane (Herdiansyah, 2020). Porosity in volcanic reservoir can be present relatively high, depending on the volcanic process in the area. The alteration (tuff to clay) can reduce matrix porosity. But dissolution and fracture that occur can increasing porosity and permeability (Sruoga and Rubinstein 2007).

Geology Condition

The Jatibarang Field is located in the west Java - Basin. This Basin is formed by deepening of the East to West trending Cirebon Trough which roughly parallels the North coast of Java. The North West Java Basin consists of two areas, that is: the sea in the north and land in the south (Darman and Sidi, 2000). The entire area is dominated by extensional faults and very minimal compressional structures. The basin is dominated by rift associated with faults that form several half graben structures (depocenters). The main depocenters formed are: Ardjuna Sub-basin and Jatibarang Sub-basin. Several other depocenters were formed, such as: Ciputat sub-basin, Pasirputih sub-basin. The reservoir that was interpreted as a synrift/continental origin of fluvial - deltaic sediment (Talang Akar Formation). Jatibarang Formation has experienced long tectonic history, resulted of intense faulting, folding and fracturing (Yudha et al, 2010).

In Jatibarang field, the Jatibarang Volcanic complex consits of Andesite lavas at the base and dacite basaltic lavas interbedded with clays, sandstone, conglomerate and pyroclastics in the upper portions (Nutt and Sirait, 1985). The fracture zone is divided into static and dynamic. In Jatibarang field continuous and discontinues conductive fracture analysis were conducted to calculate fracture intensity on each well that has FMI data. Image log data is used to calculating area, fracture length, and amount of fractures in the grid area (Herdiansyah et al, 2020).
METHODS AND MATERIALS

Static reservoir modeling is intended to obtain lithofacies and reservoir properties variations in the lateral and vertical directions and their distribution in 3D. The vertical data modeling was generated from well log and image log. While, the modeling of the structure and reservoir zoning is carried out based on the results of geological study such as well marker, lithofacies, isopach, fluid contact, pore pressure, and bulk modulus. The 3D static model was generated to distribute the lithofacies and reservoir properties into a 3D grid model using a deterministic and/or stochastic approaches. Geological model can be visualized vertically and laterally. The following stages in static modeling are structural modeling, stratigraphic modeling, facies modeling, total porosity modeling and fracture porosity modeling. 3 volcanic cycles within the Jatibarang field that are cycle 3, cycle 2, and cycle 1. In the Jatibarang field there are Sixteen faults configuration of structures with a North-South direction and be divided into 2 segments (figure 1).

![Figure 1. Fault configurations, horizon model, and compartment in the Jatibarang Field](image)

RESULT AND DISCUSSION

The low values of gamma ray shows lava lithology, this is also confirmed by thin section data. High gamma ray value indicate that lithology is tuff. The FMI data shows that the tuff layer has been fractured. Tuff is separated into lithic tuff, vitric tuff, and crystal tuff based on petrography and based on log characters. From the results of thin section not only fresh tuff but also tuff has been altered. The altered tuff shows increased gamma ray, increased conductivity, and reduced density. In contrast to tuffs, andesite lava has a high gamma ray, relatively higher resistivity values. The facies distribution map is generate by separating tuff lithology as a reservoir and non-tuff lithology which is assumed non reservoir. Non-tuff consist of andesite and breccia lava with littoral and supralitoral depositional environments. The distribution of the facies map based on the geological aspect has a South-North direction (figure 2).
Figure 2. 3D facies distribution of cycle 3, cycle 2, and cycle 1

The pore pressure and bulk modulus models are distributed based on 92 wells which have bulk modulus data. Then the pore pressure distribution and bulk modulus are used as co-krigging to distribute the total porosity and fracture porosity models. In the Figure 3 color gradation from blue to red, where blue indicates areas that have low pore pressure. Then, in the Figure 4 the red color shows areas that have high bulk modulus. Low pore pressure and high bulk modulus values indicate that these areas have high fracture intensity.

Figure 3. Pore pressure distribution of cycle 3, cycle 2, and cycle 1
The total porosity has been evaluated from petrophysical analysis based on geophysical well log data, and validated by routine core analysis. It was upscaled and distributed using a variogram which is collocated-co kriging with bulk modulus. The distribution of porosity has a relationship with fracture intensity, it can be seen from the bulk modulus distribution (Figure 5).
Fracture porosity was estimated from FMI data. Calculating the area, fracture length in the area, and aperture in JTB-159 and JTB-120 wells. The area adjusts the resolution of the FMI reading on the FMI image, which is 13 cm (lateral) x 100 cm (vertical) so that the area obtained is 0.130 m², so the grid in geological modeling adjusts the FMI area, which is 100 cm vertically. The steps in distributing fracture porosity are by calculating the fracture intensity*aperture (I*A) in the JTB-159 well and then distributing it to wells that have porosity values (PHIT) but do not have FMI based on the crossplot I*A vs bulk modulus (Figure 6).

![Figure 6. Fracture porosity distribution of cycle 3, cycle 2, and cycle 1](image)

**CONCLUSION**

Multiplication of fracture and aperture corresponds to the fold intensity and fracture intensity. Wherein the higher fold intensity, the I*A values will be high and the higher fracture intensity then the I*A values will be high. Likewise, the bulk modulus is high, I*A will be high with a linear relationship. The distribution of porosity has a relationship with fracture intensity and fracture intensity, it can be seen from the bulk modulus distribution. Low pore pressure and high bulk modulus values indicate that these areas have high fracture intensity.

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