CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Permeability equations from porosities in uncored well have been developed from simulated porosities in this study. The procedure can be divided into two steps: Sequential Gaussian Simulation and permeability equations from porosity and application. For Sequential Gaussian Simulation, a variogram model represents the spatial variability structure of porosity data and was used as a conditioning information in simulation process. Cross validation was used for checking the reliability of the variogram before inputs into SGS process, and it shows a good correspondence with the original data structure. The realization maps of porosity were simulated by Sequential Gaussian Simulation. In the second step, the relationship between porosity and permeability were established and tabulated into equation by using hydraulic flow unit (HFU) method. Finally, two cases of calculated permeability and simulated porosity were then compared in terms of production performances in reservoir simulation program.

In this study, 147 porosity values of well log data are taken from 14 wells located within an area of 9 km^2 were selected. Then, the variogram models of porosity, which best fitted with gaussian and spherical models were quantified in each representative layer. Sequential Gaussian Simulation was used to generate 16 realizations using porosity data and its variogram model as conditioning data. These 16 relizations at each depth of permeability value obtained from core analysis were located. After that, hydraulic flow unit was used in determining permeability equation for each HFU. Three permeability equations were identified for three HFUs. Simulated porosity and porosity from well logging data were used to determine permeability in order to confirm that the obtained permeability equations are able to estimate permeability in this field. Next, a comparison of calculated permeability values and coefficient correlations between the calculated and measured permeabilities from hydraulic flow unit method with the other permeability-porosity

relationships such as logarithm of permeability and porosity and Jorgensen method were considered. The results show that the HFU method performs better than the other methods in relation to correlation and calculated permeability. Finally, three cases of porosity and permeability were assumed in reservoir simulation program. The simulated porosity from two different realization maps and their corresponding permeability were used as inputs in case I and case II, while the core measured permeability and porosity were used as inputs in case III. The results of production profiles were compared.

Important remarks on Sequential Gaussian Simulation are presented as follows:

1. The variogram for all sampled data shows no spatial correlation structure. Variogram analysis in each layer is preferable.
2. A lognormal distribution with positive skewness is fairly represented porosity data. The gaussian and spherical models are reasonably well fitted for experimental points variogram of porosity data.
3. A number of conditioned data in cross validation process should be carefully selected. The estimated values approach the data mean when more conditioned data is used. This is because of a smoothing property of Kriged estimation.
4. Sequential Gaussian Simulation provides simulated values in the local sense referring to its conditioning information which includes the nearest data available comprising both original data and previously simulated data. The quality and quantity of simulated value mainly depend on spatial correlation captured in the variogram model.

In the second part, important points on determining permeability equation from porosity using hydraulic flow unit and its application can be summarized as follows:

1. There are many cluster analysis that can classify the number of permeability equation. However, graphical clustering methods such as

histogram analysis and probability plot are often used due to their simplicity and adequate accuracy of the results.

2. Hydraulic flow unit method was used to determine the permeability equations. Three permeability equations were obtained from cluster analysis.
3. HFU shows the coefficient correlation of 0.658 while other methods provide the negative coefficient correlation in the range of -0.345 to -0.383. This can be inferred that permeability equations based on hydraulic flow unit provide a good estimation of permeability at uncored wells in this field.
4. Two cases of different simulated porosity and calculated permeability in reservoir simulation program provide slightly different results. This indicates that permeability equations are able to estimate permeability efficiently in this oil field.
5. It is important to note that there is a significant difference between the core-measured porosity and simulated porosity which has significant impact on permeability estimation. According to permeability equations obtained from core measured porosity, a substitution of simulated porosity yields lower permeability estimation, thus effecting the production profiles especially the total water production.

The following points are recommended for future study:

1. In this study, only seven permeability data from core analysis were used to determine permeability equations. The correlation between the calculated and measured permeability shows coefficient correlation of 0.658. Therefore, in order to provide more accurate result in permeability estimation, future study should be concentrated on increasing the number of measured permeability from core analysis.
2. For future study, Sequential Gaussian Simulation can be applied to simulate permeability data obtained from permeability equations. The simulated permeability data are compared with the measured core permeability in well test analysis.

3. If a situation arises when there are more variables available in the study area, the addition information should be incorporated into the simulated model. Many variables can be simultaneously simulated through the cosimulation model. In this manner, the accuracy of the estimated will be improved in accordance with the amount of input information.