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HIERARCHICAL 3D MODELING IN COMPLEX CARBONATE RESERVOIR by COMBINING DETERMINISTIC AND STOCHASTIC APPROACH

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ABSTRACT

This paper shows how to model the 3d complex carbonate reservoir by combining deterministic and stochastic method. 3d facies model is the most important step in building reservoir static model because the distribution of another properties will depends on this model. a good facies model is needed in building a good model. The nature complexity of carbonate facies itself makes the modeling are even more chalangging. Deterministic geological interpretation is modelled by trend modeling while the rock type distribution is distributed inside each facies stochastically. This field is divided into five zones. These zones represent depositional cycle occurred within carbonate formation. The facies is divided into four facies; Reef, Lagoon, Platform, and slope. a reservoir rock type was done by using RT distributions. According to Geological concept, reservoir quality distributions have different trend either vertical or horizontal. Horizontally, a good reservoir should be located in Reef facies and the poor reservoir quality should be located in slope facies. Vertically, reservoir quality should get better from bottom to top in every reservoir zone

***Keywords**: Pore types, Diagenetic prosses, Carbonate Reservoir*

INTRODUCTION

3D geological modeling is one of the chalanging work that has to be done in Oil and Gas industry. This activity combined the data from geophysics, petrophysics, Reservoir analysis and geological interpretation. Facies modeling is the first model that has to be done, the quality of this model determined all the petrophysical model after. This paper describe how we model the complex carbonate facies model.

METHOD

3D reserfoir modeling in this study comprises several step, including:

Structural modeling - it is a process to construct a geometry model. Structural modeling was done using depth structure map from seismic interpretation and well tops within study area. Structure map are horizons and fault in depth domain. Fault modeling was started from converting fault interpretation based on seismic data into fault plane. During fault conversion, the process should minimize 3DGrid error and accommodate geological concept. Faults used in this model are major faults passing through targeted geological formation. These fault are major fault in the field. After all fault was modeled, pilar grid are builded. Pillar gridding is a step of making initial 3D model. These pillars are made by using key pillars and trend. The distance between pillars called as grid size chosen by considering field situation such as wells spacing and the reservoir simulation requirement.This model uses 50 x 50 m grid size. This size was chosen since average wells spacing is 200 m, so it will be more than two grids between wells

This field is divided into five zones. These zones represent depositional cycle occurred within carbonate formation. The basic assumption of this zones making is that there are same cycle within every zone showed by porosity log pattern. In every zone porosity log shows a good trend from bottom to top (Figure 1).

Zones making was created by using conformable method. This method create horizon model which is not covered by seismic picking.

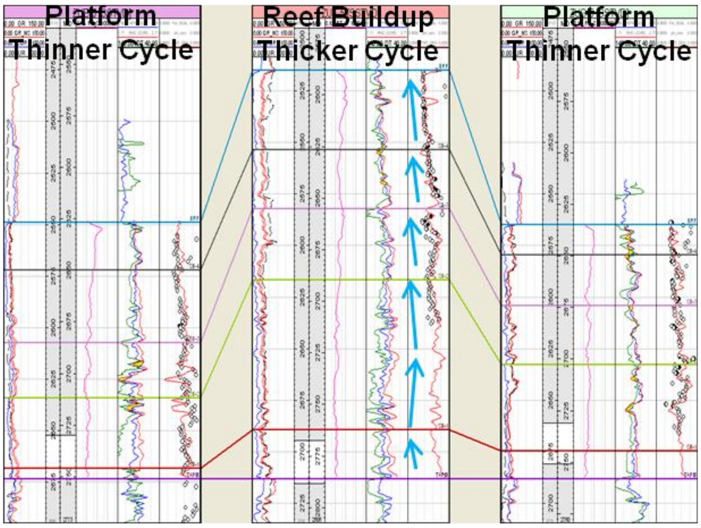


Figure 1. Zone division based on porosity log curve

Layering was created for every reservoir zone. the number of layer is selected by considering the total number of final 3D grid while considering well logs data when upscaling from logs into grid model (Figure 2).Before moving to the next step, 3D Grid model quality control was done. The main purpose of this step is to see whether the model has an optimum grid sizes so that up scaled well log data reflect its original data and to avoid any reservoir simulation obstacle due to erroneous 3DGrid model. The up scaled well log data within the model are shown by histogram distribution. The more similar histogram distribution between up scaled data and original data is, the better model we made. In this case, the distribution of up scaled and original data are alike (Figure 3). The quality control of 3DGrid consists of two steps. First, there are no folded grids which will produce negative bulk volume. Second, avoid any triangular (not orthogonal) grids making reservoir simulation be longer.

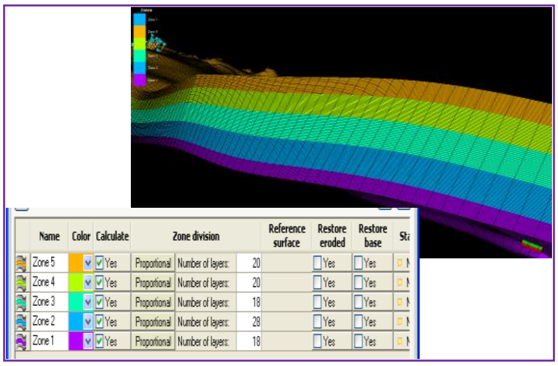


Figure 2. Layering division

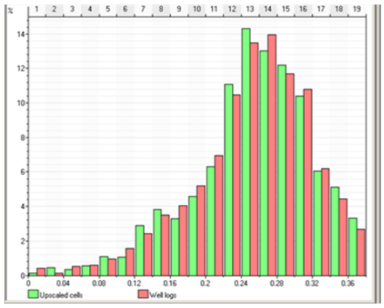


Figure 3. Histogram of original logs and upscaled cells

RESULT AND INTERPRETATION

- The Concept of Facies Model

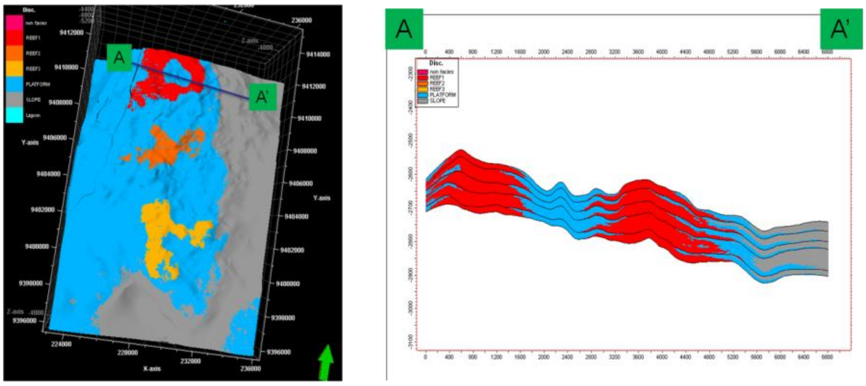
Facies modeling was performed because there are facies separation in this field. Each of these facies shows different properties characteristic and different porosity to permeability transform. The facies is divided into four facies; Reef, Lagoon, Platform, and slope. The best properties quality is Reef facies. Lagoon and Platform facies have moderate properties quality. Whether slope facies has the worse properties quality.

- Facies Classification Methodology

The methodology to differentiate between one facies to the others is; isopach map, water chemistry, and seismic acoustic impedance. From isopach map, the facies is divided into two facies. Reef and non-Reef facies. Reef facies is shown by thick isopach map, while non-Reef facies is shown by thin isopach map. Water chemistry confirms that Reef facies has different water chemistry compared to Platform facies. Seismic acoustic impedance shows slope facies has high acoustic impedance.

- Facies Modeling

To accommodate the complexity of carbonate model, facies model was done separately for each facies. First, each of facies was created, then combine the entire facies model into group of facies model covering study area. Gaussian simulation was used to generate facies model. Facies modeling was done for every zone. Each of zones shows similar trend between one to the other. This similarity trend shows depositional cycle (Figure 4).



(a) (b)

Figure 4. Facies Model: (a) plane view, (b) Cross section

- Rocktype Modeling

Reservoir rock types could be distributed either by distribute RFN (rock fabric number) or by distribute RT (rock types). It is easier to distribute RT rather than to distribute RFN, as RT in discrete data which is easy to keep vertical probability distributions where RFN is continues data. This time, a reservoir rock type was done by using RT distributions. According to Geological concept, reservoir quality distributions have different trend either vertical or horizontal. Horizontally, a good reservoir should be located in Reef facies and the poor reservoir quality should be located in slope facies. Vertically, reservoir quality should get better from bottom to top in every reservoir zone (Figure 5).

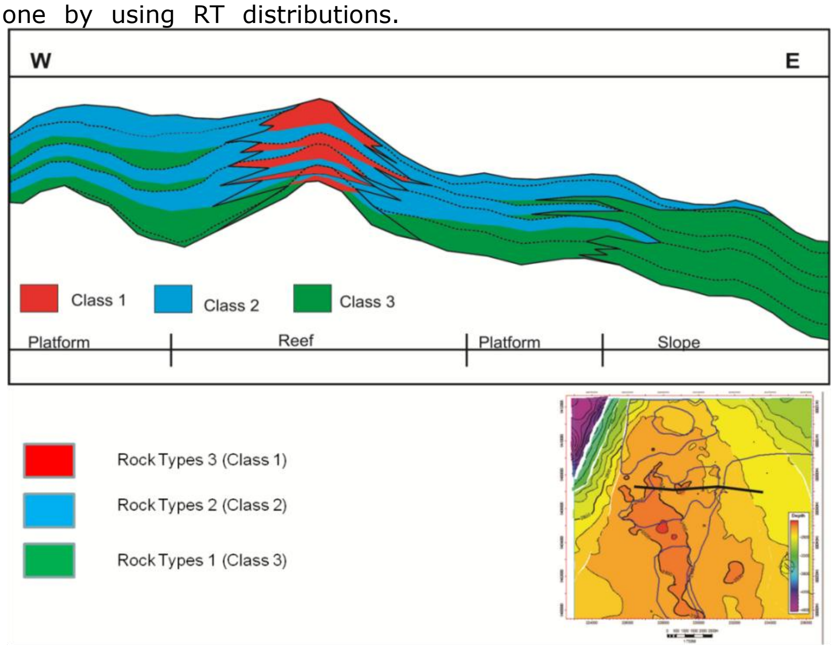


Figure 5. Conceptual Rock Types Distribution

Before doing reservoir types distribution in modeling process, data analysis was done. This data analysis is intended to keep rock types probability distribution within each facies. So the probability of reservoir types would be stayed for every facies and every zone (Figure 6).

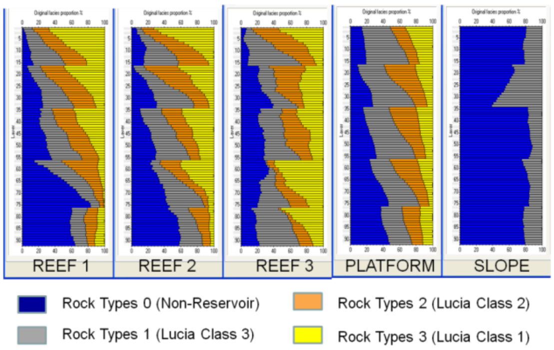


Figure 6. Rock types data analysis

Finally, Rock Types distribution could be distribute based on data analysis and variogram for each facies and each zone resulting Rock Type Distribution as shown in Figure 7.

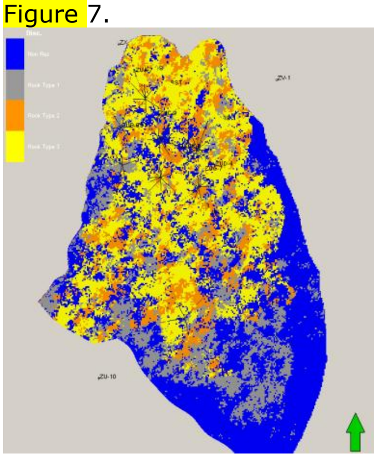


Figure 7. Rock Types distribution

Conclusion

Hierarchical reservoir modeling in this study shows better result. Distribution of geological facies that controlled by geological interpretation could be applied on to model using vertical trend. The quality of the geological model facies must be controlled by deep geological knowledge acros the field by geologist. Further more, the distribution of rock type model is very hard to control and to be scored whilist it is good or not, but statistically the model could be liable. The distribution of rock type also could be controlled using relative distribution on each its geological facies, so this approach is much better when compared to just modeling with statistical parameters.

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