SAND DISTRIBUTION MODELING OF MIDDLE MIOCENE RESERVOIR OF "EAST TARAKAN A FIELD" IN EASTERN PART OF TARAKAN ISLAND, EAST KALIMANTAN

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ABSTRACT

The discovery well with initial name "East Tarakan A-1" was drilled in February 2007 to a total vertical depth of 10,000 feet and encountered gas reservoir in Middle Miocene-age sands with deltaic sediment facies. The Field is structurally high, faulted to the Mengatal producing zones. This sandstone is hydrocarbon producer in most of onshore fields of Tarakan Island. "East Tarakan A" Field has been suppported with 19 (nineteen) 2D Seismic data. There are three wells i.e: East Tarakan A-1, A2b and A3 with several logs data, mud log and biostratigraphic data.

The study aims are firstly to built 3D structural model from time and depth structural maps based on seismic interpretation and well log analysis, secondly to create 3D properties model especially volume shale (V-shale) to get sand distribution. The sand distribution model is supported by 3D structural model, petrophysical analysis and seismic attributes as well as geo-statistic method.

Based on petrophysical analysis and wells correlation, sand reservoir interval of Middle Miocene (Meliat Fm) can be devided into two zones respectively top to bottom; zone-1 dan zone-2. RMS Amplitude analysis has been used to help constrain the sand distribution. Sand distribution with two zones indicates that sand distribution of zone-1 and zone-2 are generally located in distributary channel delta. NTG Distribution model of zone-1 and zone-2 indicates that reservoir zone distributed in distributary sand with trend of west to east. NTG of zone-1 is relatively better reservoir than the zone-2.

Keywords: Tarakan, Middle Miocene, V-shale, sand distribution, 3D model, NTG

SARI

Sumur penemuan dengan nama inisial "East Tarakan A" telah dibor pada Februari 2007 dengan total kedalaman 10.000 kaki dan dijumpai reservoir gas pada lapisan pasir berumur Miosen Tengah dengan fasies sedimen delta. Lapangan gas ini berupa struktur tinggian dan patahan bersebelahan dengan zona produksi Lapangan Mengatal. Batupasir sebagai batuan reservoir merupakan lapisan utama penghasil hidrokarbon di lapangan onshore di Pulau Tarakan. Lapangan "East Tarakan A" didukung oleh data 19 penampang seismik 2D. Terdapat pula tiga

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sumur pemboran yaitu Tarakan A-1, A-2b dan A3 dengan beberapa data log sumur, mud log dan biostratigrafi.

Studi ini dilakukan dengan maksud dan tujuan, pertama, membuat model stuktur geologi 3-dimensi dari peta struktur waktu dan kedalaman berdasarkan interpretasi seismic, analisis log sumur. Kedua, menghasilkan property model khususnya volume serpih (V-sh) untuk akhirnya memperoleh distribusi pasir. Model sebaran pasir didukung dengan model struktur 3D, analisis petrofisika dan atribut seismik serta metode geo-statistik.

Based on petrophysical analysis and wells correlation, sand reservoir interval of Middle Miocene (Meliat Fm) can be devided into two zones respectively top to bottom; zone-1 dan zone-2. RMS Amplitude analysis has been used to help constrain the sand distribution. Sand distribution with two zones indicates that sand distribution of zone-1 and zone-2 are generally located in distributary channel delta. NTG Distribution model of zone-1 and zone-2 indicates that reservoir zone distributed in distributary sand with trend of west to east. NTG of zone-1 is relatively better reservoir than the zone-2.

Berdasarkan pada analisis petrofisika dan korelasi antar sumur pemboran, lapisan reservoir pasir Miosen Tengah (Formasi Meliat) dibagi menjadi dua zona yaitu Zona-1 di bagian atas dan zona-2 di bawahnya. Analisis amplituda RMS pada data seismik digunakan untuk membantu penyebaran sedimen pasir. Sebaran pasir dengan dua zona menunjukkan secara umum keterdapatan pasir di area distributary channel delta. Model distribusi NTG (net to gross) pada zona-1 dan zona-2 memperlihatkan area reservoir berada di bagian pasir pada distributary channel dengan arah barat ke timur. NTG pada zona-1 relatif lebih baik daripada zona-2.

Kata kunci: *Tarakan, Miosen Tengah, V-serpih, sebaran pasir, NTG*

INTRODUCTION

The discovery well with initial name "East Tarakan A-1" was drilled in February 2007 to a total vertical depth of 10,000 feet (3,274 meters) and encountered gas reservoir in Middle Miocene-age sands with deltaic sediment facies. The discovery well is located approximately 6 kms east of Mengatal Oil Field and in easter part of Tarakan Island (Figure 1). The prospect is structurally high, faulted to the Mengatal producing zones. This sandstone is hydrocarbon producer in most of onshore fields of Tarakan Island.

Objectives of this research are firstly to built 3D structural model from time and depth structural maps based on seismic interpretation and well log analysis, secondly to create 3D properties model especially volume shale (V-shale) to get sand distribution. The sand distribution model is supported by 3D structural model, petrophysical analysis and seismic attributes.

REGIONAL GEOLOGY

East Tarakan Field is located in the Tarakan Basin especially of Suikerboard Ridge. Tarakan Basin is bounded by the uplifted pre-Tertiary core of Kalimantan on the West and opens Eastwards and Southeastwards into the Straits of Makassar. To the North, it is bounded by the Semporna Fault and the Semporna Volcanic Ridge. The later defines the Southwestern most termination of the Sulu volcanic arc. To the South, the Mangkalihat Peninsula and Mangkalihat Fault define the boundary between the Tarakan Basin and the Kutai Basin.

East Tarakan Field is situated on the North-Easternmost part of the Tarakan Island. The structure is located on the up-thrown side of the reverse fault, approximately six km East of Mengatal Oil Field. It is structurally high, faulted to the Mengatal producing zones. The structure is formed as thrusted anticlinal structure along the North-South oriented East Tarakan Fault. Seismic interpretation indicates that the structure is formed by an Easterly

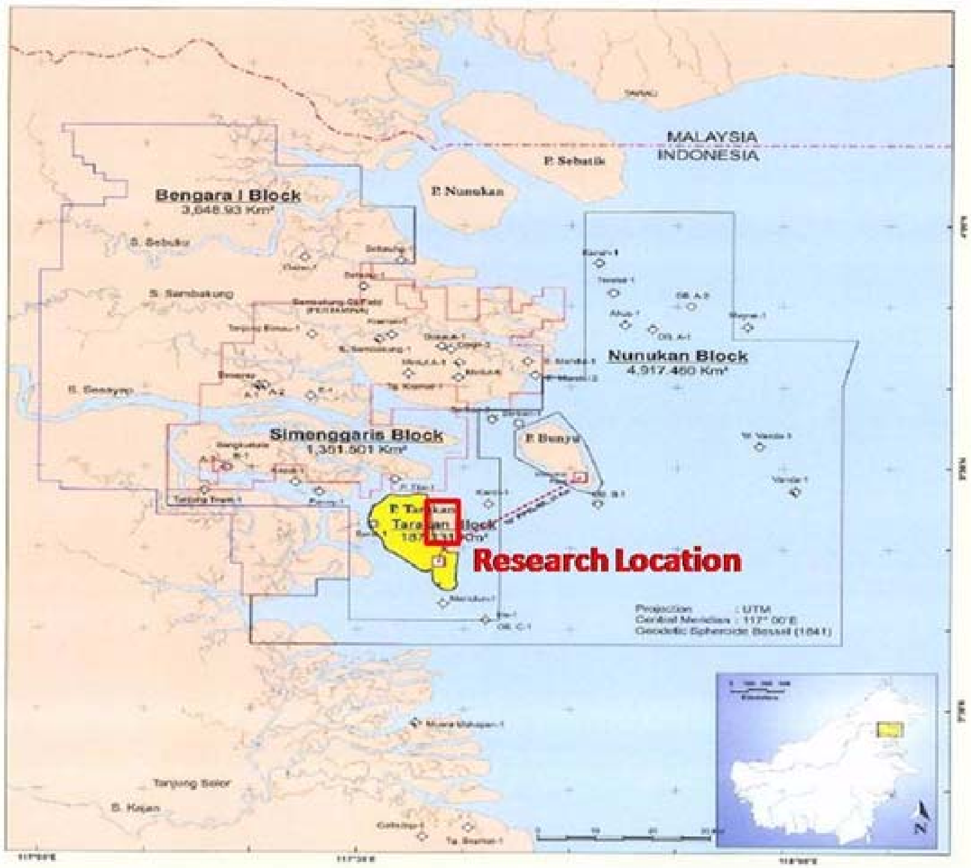

Figure 1. Study area of "East Tarakan" Field as a gas field in Eastern Part of Tarakan Island, East Kalimantan

dipping of North-South trending high angle thrust fault situated on the Western margin of the North-South trending anticlinal structure

In general, the existing or proven oil and gas fields are formed by a combination of structural and stratigraphic trapping along the axis of Southeasterly plunging Tarakan arch into Plio-Pleistocene reservoirs deposited in a very proximal to delta plain depositional setting.

Tarakan sub-Basin that will be a research location was located in the middle of the mouth of the Sajau River (Figure 2.a). Based on the results of structural analysis and sedimentation processes, Tarakan sub-basin can be divided into five geological regions, namely: Exposure-Sebuku Daino, Graben/sub-Deposenter Sembakung-Bangkudulis, Dasin-Fanny ridge, slope-Tibi and Mintut primarily Bunyu Deposenter - Tarakan (Figure 2.b).

Tectonostratigraphy in Tarakan Sub-basin can be divided into three phases; pre-Rift, syn-Rift and Post-Rift. In the post-Rift phase, the Tarakan Sub-basin as a passive margin was divided into transgresion and regression phases (Ellen, et al., 2008). In the regression phase, the post-rift sediments are deltaic deposits respectively Tabul, Santul, Tarakan

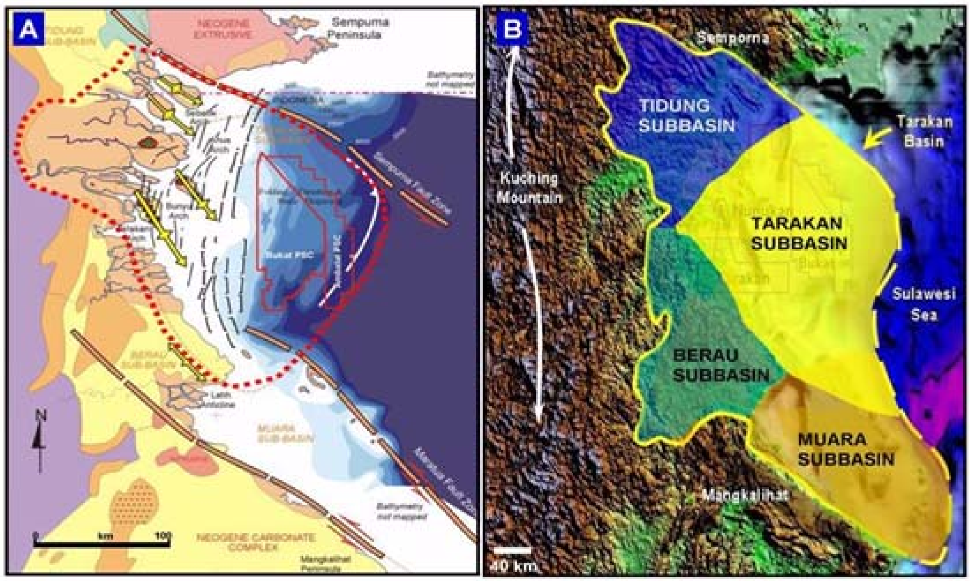

Figure 2 - a) Structure map of the Tarakan Sub-Basin (Hidayati, et al., 2007), b) Tarakan Basin can be divided into four sub-basins namely Tidung, Tarakan, Berau, and Muara Sub-Basin (Achmad and Samuel, 1984)

and Bunyu Formation. Rapid subsidence started Santul Formation resulting growth faults that continues until Tarakan Formation in Pliocene age as a cycle-4 deposition. Tectonic activities during Late Pliocene to Pleistocene change with produce compression tectonic that encountered in some mono-anticline and thrust faults. This process occurs during Bunyu Formation deposition (Figure 3).

METHODOLOGY

Geological and Geophysical Availability Data

"East Tarakan A" Field has been suppported with 19 (nineteen) 2D Seismic data i.e. 11 (eleven) crossline 2D seismic and 8 (eight) inline seismic. Generally, the quality of 2D seismic data is poor to middle quality of seismic reflector. This 2D seismic quality give difficulties impact in seismic interpretation especially on seismic horizon of Top Sand Reservoir of Middle Miocene that become a basis data of each top reservoirs from 1 to 4 There are three wells i.e: East Tarakan A-1, A2b and A3 with several logs data, mud log and biostratigraphic data. As supporting data VSP of Mengatal-1 will be used.

To determine reservoir characteristics especially sand distribution, 3D geological modeling include structural and stratigraphic model are carried out based on integrated wells and seismics data through petrophysical analysis, seismic interpretations and seismic attributes, as well as considering regional geology to be input of geological concept in petroleum system. For a reservoir with limited information it is clearly impossible to construct a model that fulfils this condition. But, it is possible to build models that are designed with different specifications. So we can build models which would respond the same as the real reservoir for a very narrow

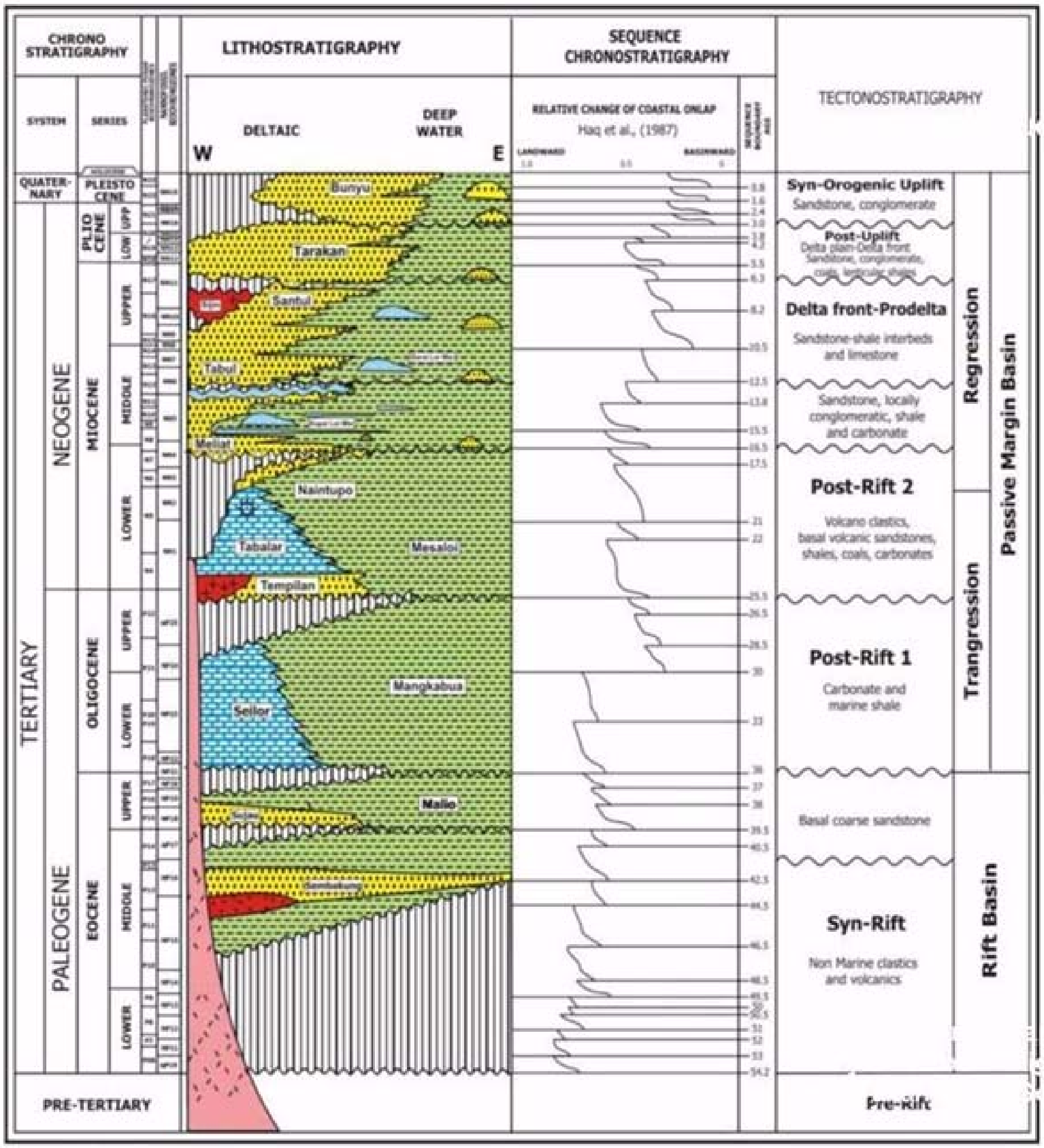

Figure 3 - Regional tectonostratigraphy includes litostratigraphy and chronostratigraphy in the Tarakan Basin (Ellen, et al., 2008)

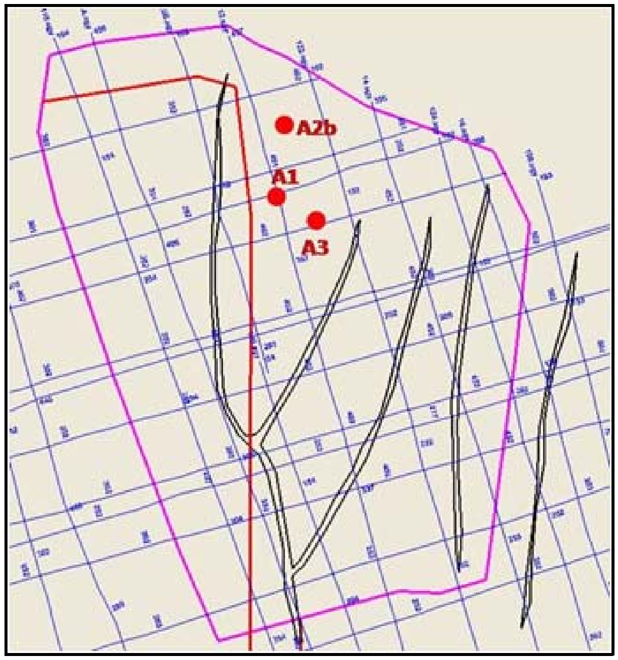

Figure 4. Base map of "East Tarakan A" Field with 19 seismic lines and 3 wells location

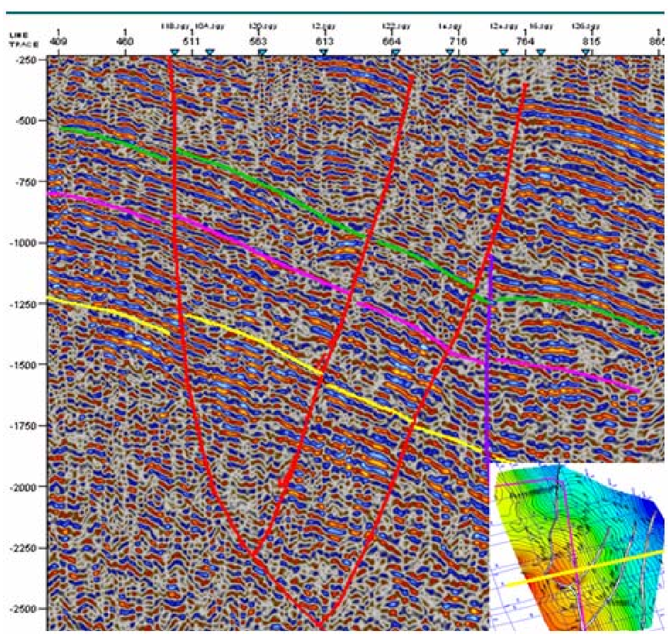

Figure 5. Seismic Interpretation of line L-111 that across the East Tarakan Field

subset of possible interrogations (Tyson and Math, 2009)

Building 3D static geological models for "East Tarakan A" Field incorporating 2D interpretation both horizons and faults, petrophysical interpretation of A1, A2b and A3 wells and well to well correlation to divide into two zone reservoirs. A new geological model will be built based on interpretations and analyses of all the available geological, geophysical and 2D Seismic data in around of "East Tarakan A" Field.

In determining reservoir properties, the integrated process between well logs and DST analysis should be done to calibrate the validity of log derived reservoir properties is carried out. Using standard formulas, reservoir properties i.e. V-shale and net porosity were obtained from gamma ray log, density – velocity combined logs respectively. Then, the analysis using cut-off values of V-sh will produce net to gross reservoir (NTG).

The upscaling process imports the well data into those cells of the model penetrated by the wells. Each cell has a single value for each property and it is derived from averaging the log values within each cell. The well data are the key input data for the property modelling, i.e. for defining the range of property values for each of the electrofacies within the model. The 1-Vsh log of well data are upscaled.

RESULT AND DISCUSSION

Seismic Interpretation

The structure was formed as trusted anticlinal structure along the N-S oriented East Tarakan Fault. Seismic interpretation indicates that the structure is formed by an Easterly dipping of N-S trending high angle thrust fault situated on the Western margin of the N-S trending anticlinal structure. Because the pay zone lays only on one wiggle, it is difficult to interpret the internal structure of the pay zone. Seismic sections of this structure are shown in **Figures 5** through **7** show structure maps along with the gas interval found as gas reservoirs.

Depth Structural Maps of Top Sand Reservoir of Middle Miocene

The depth structure maps for top horizon of top sand reservoir of Middle Miocene was obtained by conversion from the time structure map using velocity model of Mengatal-1. Velocity model of time to depth conversion from Mengatal-1 well was used to change time structural maps become depth structural maps of East Tarakan A Field .

The depth structural map (Figure 8) and 3D model of depth structural (Figure 9) show that subsurface geological setting of top sand reservoir is situated on the north easternmost part of the Tarakan Island. This field is located on the up-thrown side of the reverse fault. The field is is structurally high, faulted to the Mengatal producing zones. Seismic interpretation indicates that the prospect is formed by an easterly dipping of N-S trending high angle thrust fault situated on the western margin of the N-S trending anticlinal structure.

Well logs Analysis

Net to gross each sand reservoir was obtained from V-Shale analysis with three scenarios i.e. 49%, 51% and 54% cut off based on Gas Flow Location (DST Zones) using Volume-shale (V-sh) log obtained from GR log (Figure 10). Porosity and water saturation for each of the four sub-zones reservoirs were estimated by petrophysical analysis of well logs. Cut Off porosity and water saturation bases on Gas Flow Location (DST Zones) can be seen in figure 2. Porosity was selected from five scenarios and the final resut is the density and sonic logs; water saturations were also taken from log and calculated using the Modified Indonesia equation. The results of well logs analysis are shown in the following (Figure 11). There is strong evidence found

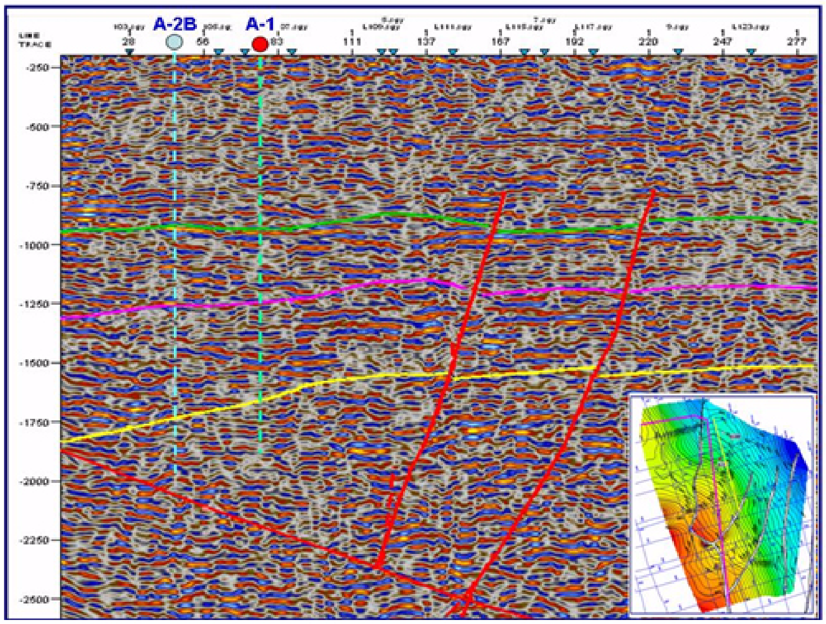

Figure 6. Seismic Interpretation of line 12SG4 that across the the East Tarakan A-1 and A-2B Well

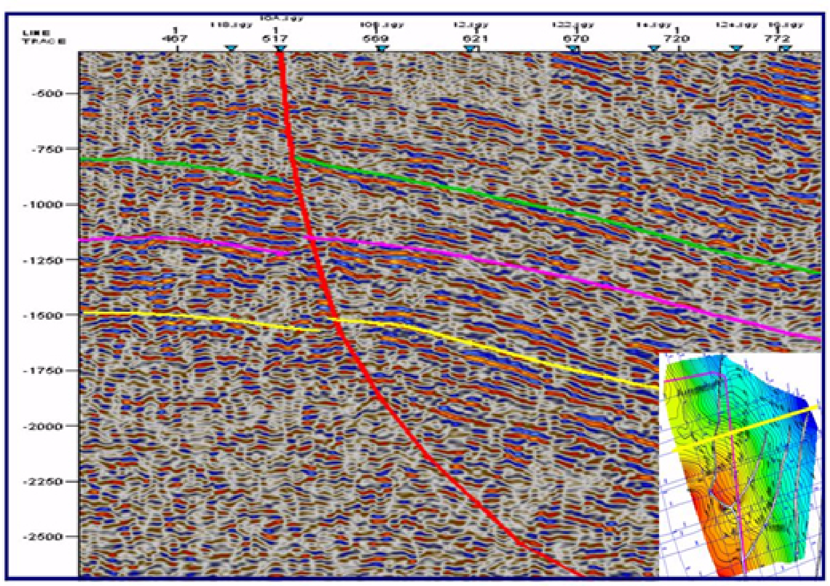

Figure 7. Seismic Interpretation of line 107 that across the East Tarakan Field

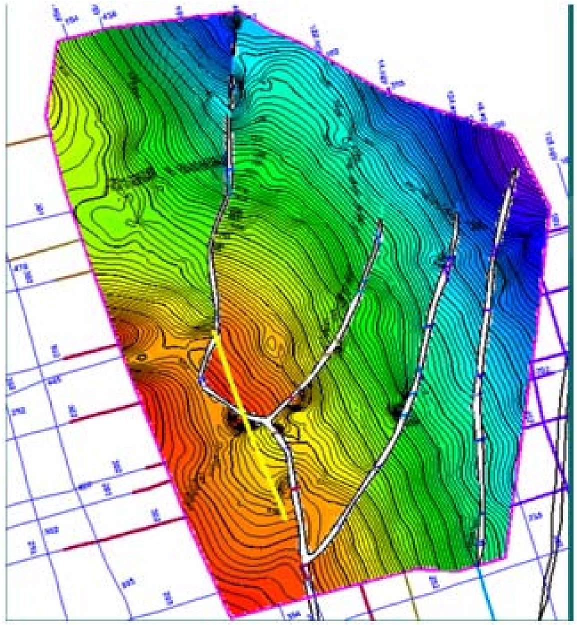

Figure 8. Depth map of Top Sand Reservoir of Middle Miocene

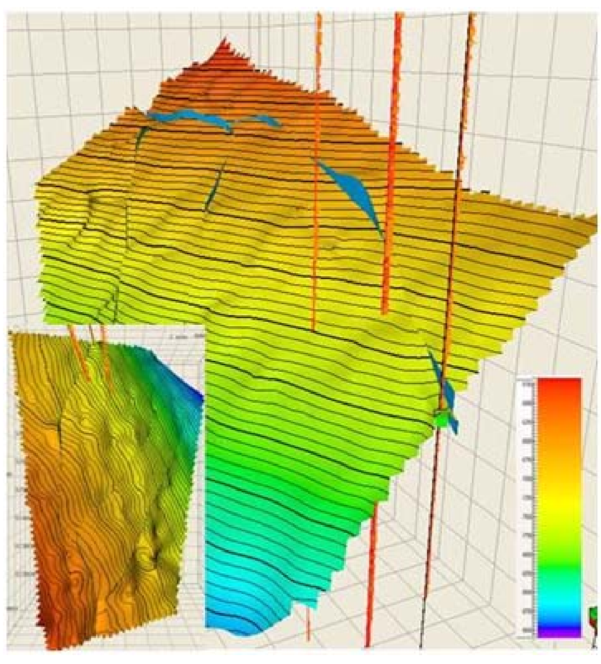

Figure 9. 3D Model of depth structural of Top Sand Reservoir of Middle Miocene

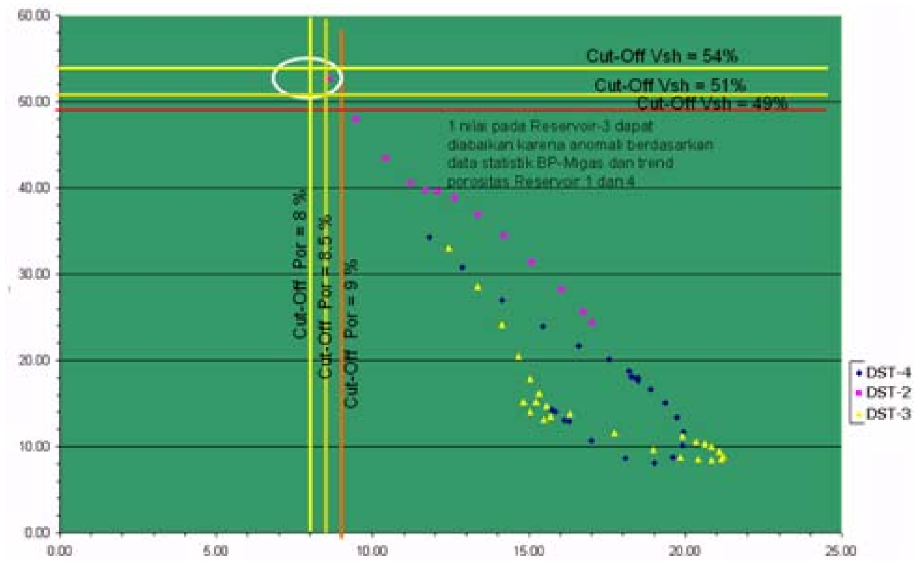

Figure 10: Cut-off Vsh and Porosity based on Gas Flow Location (DST Zones)

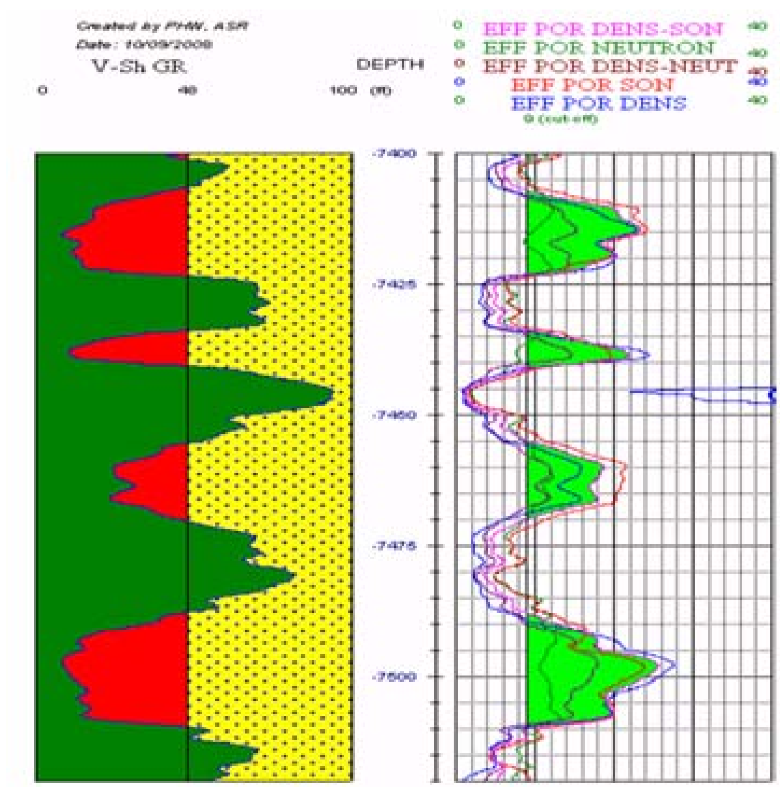

Figure 11: Petrophysical analysis to get V-sh and porosity logs

during our well logs interpretation. It was the log character that shows a blocky feature. This character usually appears on lenses depositional system at deltaic environment.

Wells correlation between East Tarakan A-1, A-2b and A-3 give two zones with corrected slope (more slightly) in northern part of anticlinal flank structure. Two Zones Reservoirs as a deltaic sediment with Middle Miocene Age (Meliat Fm: Sst, Slst, Sh, Ls stringer) Zone-1: coarsening upward, interpreted as part of regressive deltaic plain with tidal channel. Zone-2: fining upward, interpreted as part of transgressive deltaic plain with tidal channel (Figure 12). Based on biostratigraphic analysis of well East Tarakan A-1, reservoir zone is located on intertidal to shallow inner neritic environment. Sequence stratigraphic analysis was focused on deltaic tidal and fluvial delta concept.

Static Modeling of East Tarakan Island Area

Upscaling Well Log Data

The upscaling up process imports the well data into those cells of the model penetrated by the wells. Each cell has a single value for each property and it is derived by averaging the log values within each cell. The well data is the key input data for the property modelling, i.e. for defining the range of property values for each of the electrofacies within the model. The V-shale log of well data was upscaled. Upscaling to an average layer thickness of 7 ft has effectively captured the logs heterogeneity. The upscaled log values corresponding well with input log curves can be seen in histogram (Figure 13).

Petrophysical Modelling

The petrophysical modelling populates the static model with petrophysical properties, using the upscaled well data as calibration. Sequential Gaussian Simulation (SGS) is a stochastic simulation using an algorithm and co-kriging of facies analysis of Root Mean Square (RMS) Amplitude that ensures the modelled property having a normal distribution that honours the input data. This is often applied in areas with sparse well control. V-shale, porosity and permeability.

Facies Analysis from RMS Amplitude Generating

RMS may map directly to hydrocarbon indications in the data and other geologic features which are isolated from background features by amplitude response. This method is responsible for facies analysis and quantity of reservoir characteristic which based on seismic data. Figure 14 shown in below obtained from RMS amplitude generating for seismic facies analysis. Yellow facies was indicated as potential sand reservoir that gas accumulations have been trapped.

1-Vsh or Sand Distribution

1-Vsh or sand distribution with two zones used scale up V-sh log of 3-Wells and Sequential Gaussian Simulation with Co-Kriging of RMS secondary variable (Figure 15). The result indicates that sand distribution of zone-1 and zone-2 are generally located in distributary channel delta and its around with shaly sand to sand deposit (55 – 85% contain sand) found in central and northern central of research areas (Figure 15). The trend of distributary channel is west to east and its condition also shows source sedimentation of western area.

Sand distribution of zone-1 is relatively similar with zone-2. In around of three wells area, sand distribution of zone-1 was found more dominantly sandy deposit than the zone-2 has shaly deposit.

Net to Gross (NTG) Modeling

NTG Distribution used Boolean Logic in Calculator with three scenarios i.e. low, mid

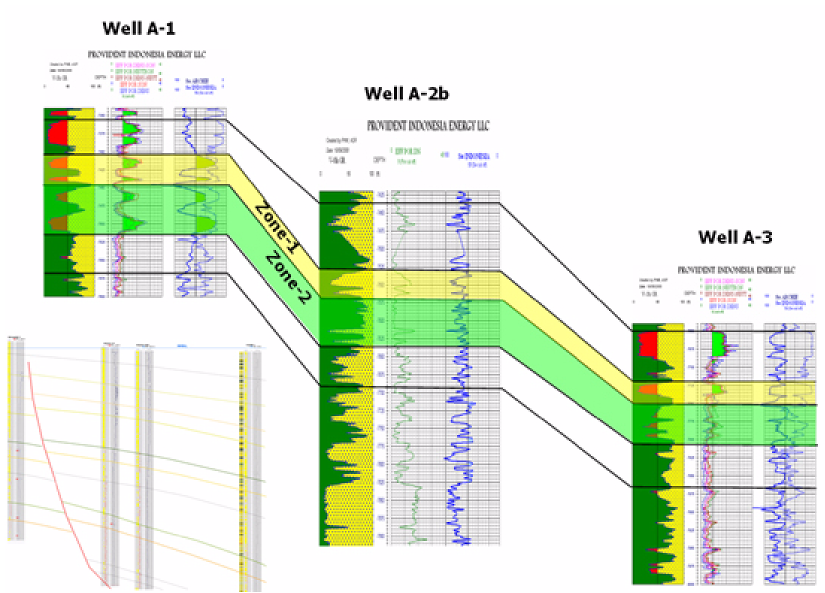

Figure 12: Well to well correlation of East Tarakan A-1, A-2b and A-3

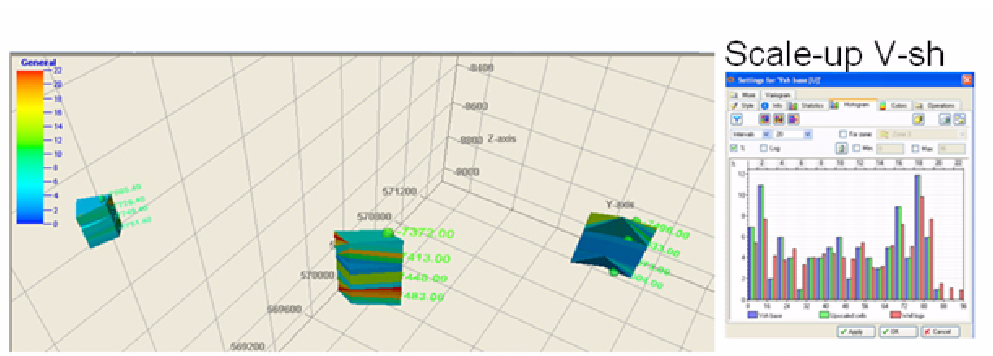

Figure 13. Upscalling Bayan A1, A2b and A3 well-logs data of V-shale

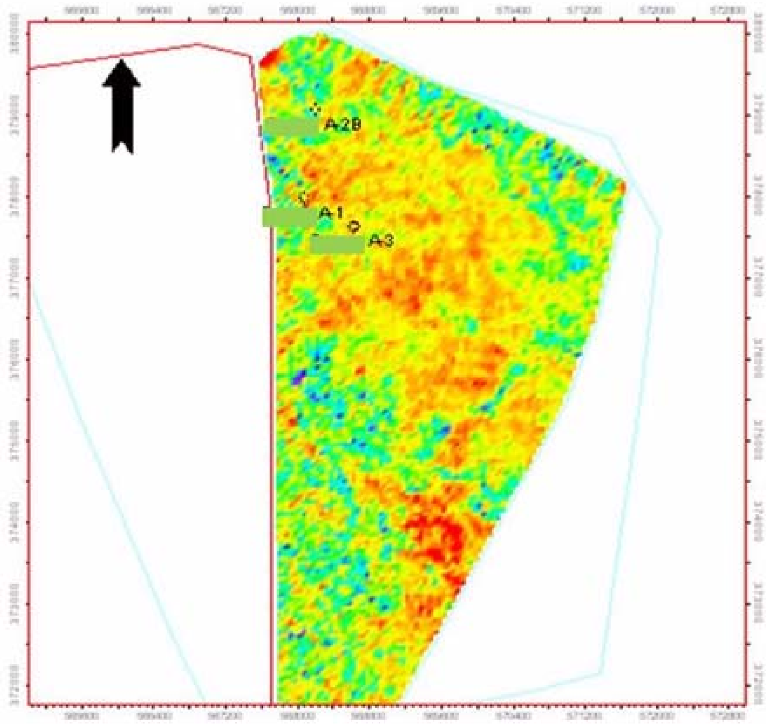

Figure 14. Facies seismic based on RMS Amplitude with 20ms below Top Sand 7000

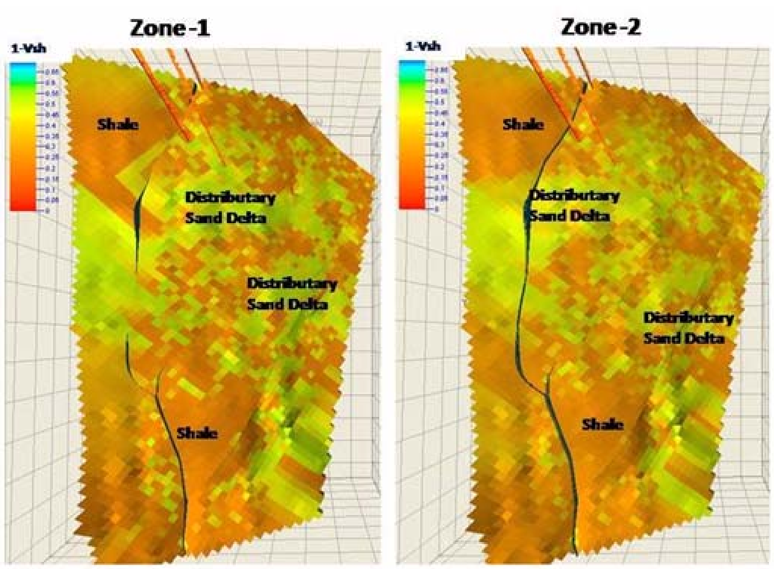

Figure 15. Two zones of 1-Vsh or sand distribution after upscalling well

Figure 16. NTG distribution based on Vsh cut-off using mid-scenario in two zones of reservoir

and high (Figure 10). Low scenario is cut-off Vsh = 49% and Porosity = 9.0%. Mid scenario is Cut-off Vs=51 and porosity = 8.5%. High scenario is cut-off Vs = 54% , Porosity = 8.0%.

The result shows that green colour area is reservoir zone but the red area is non-reservoir zone. NTG model of zone-1 and zone-2 indicates that reservoir zone distributed in distributary sand with trend of west to east. NTG of zone-1 is relatively better reservoir than the zone-2.

CONCLUSION

The depth structural map of top sand based on seismic interpretation and well log analysis show that subsurface geological setting of top sand reservoir of Middle Miocene is situated on the north easternmost part of the Tarakan Island. "East Tarakan A" field is located on the up-thrown side of the reverse anticlinal fault.

Based on petrophysical analysis and wells correlation, sand reservoir interval of Middle Miocene (Meliat Fm) can be devided into two zones respectively top to bottom; zone-1 dan zone-2.

RMS may map directly to hydrocarbon indications in the data and supporting to consideration of sand laterally distribution. RMS Amplitude analysis has been used used to help constrain the sand distribution.

1-Vsh or sand distribution with two zones indicates that sand distribution of zone-1 and zone-2 are generally located in distributary channel delta and its around with shaly sand to sand deposit found in central and northern central of research areas.

NTG Distribution model of zone-1 and zone-2 indicates that reservoir zone distributed in distributary sand with trend of west to east. NTG of zone-1 is relatively better reservoir than the zone-2.

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