3D PROPERTIES MODELING TO SUPPORT RESERVOIR CHARACTERISTICS OF W-ITB FIELD IN MADURA STRAIT AREA

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ABSTRACT

The gas field, initial named W-ITB Field, is located at the southwestern part of the East Java sedimentary basin in Madura Strait area. W-ITB Field was discovered by W-ITB#1 well in 2006. In W-ITB#1 well gas reservoir layer was just only found at Selorejo and Mundu Formation, on the other hand, on W- ITB#2 the gas reservoir is not found in Mundu Formation.

Determination of reservoir characteristic including the distribution and quality at W-ITB Field, was done by using 3D geological modelling both for structure and stratigraphy. This model was executed based on integration of well data (petrophysics) and cross section seismic interpretation.

The results, at Zone 2 and Zone 3 for vertical V-shale distribution shows as a good quality reservoir (0-15%). Laterally distribution, area at southwest of W-ITB 1 well has low V-shale or chatagorized as a good quality reservoir. While, porosity distribution, zone 1 and zone 2 have better reservoir (29-35% V-shale value) than Zones 3 and 4. NTG distribution result indicates that zone 2 and 3, with high value means a good reservoir. Due to only two exploration well, to guide lateral distribution, so that acoustic from seismic data is used for porosity distribution.

Key words: modelling, reservoir, characteristic, V-shale, porosity, quality, Madura Strait

SARI

Lapangan gas dengan nama inisial W-ITB terletak di bagian barat daya cekungan sedimen Jawa Timur yang termasuk di wilayah Selat Madura. Lapangan ini ditemukan dari Sumur W-ITB#1 pada tahun 2006. Pada sumur W- ITB#1 Lapisan reservoir yang mengandung gas hanya dijumpai pada Formasi Selorejo dan Mundu, namun dari hasil sumur W- ITB#2, lapisan reservoir gas dalam Formasi Mundu tidak diperoleh.

Penentuan karakteristik reservoir termasuk distribusi dan kualitasnya di Lapangan W-ITB dilakukan dengan pemodelan geologi 3-Dimensi baik secara struktur dan stratigrafi dengan berdasarkan pada integrasi data sumur pemboran dan penampang seismik yaitu analisis petrofisik dan interpretasi seismik.

Berdasarkan pemodelan 3-Dimensi, pada Zone-2 dan Zone-3 untuk distribusi V-shale secara vertikal merupakan zone dengan kandungan reservoir yang baik dengan nilai V-sh 0 – 15%.

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Secara distribusi lateral, wilayah di bagian barat daya dari sumur W- ITB#1 memiliki kandungan V-sh yang rendah atau dikategorikan reservoir dengan kualitas baik. Adapun pada distribusi porositas, Zona-1 dan Zona-2 mengandung reservoir yang lebih baik dengan nilai 29-35% daripada Zona-3 dan Zona-4. Hasil distribusi NTG mengindikasikan bahwa Zona-2 dan Zona-3 dengan nilai tinggi mengandung reservoir yang baik. Karena hanya memilki dua sumur eksplorasi, untuk memandu distribusi lateral maka hasil impedansi akustik dari data seismik digunakan untuk distribusi porositas.

Kata kunci: *pemodelan, reservoir, karakteristik, V-serpih, porositas, kualitas, Selat Madura*

INTRODUCTION

The gas field, initial named W-ITB Field, is located eight kilometers to south of Madura island. It is situated in the southwestern part of the East Java sedimentary basin. This field is controlled by an inversion structure that has been active since Early Pliocene times. The gas field is a part of the eastern inversion structure which is one of a series of east-west trending anticlines that were created along the inversion zone (Figure 1).

Objectives of research are firstly to built 3D structural model from time and depth structural maps, secondly to create 3D properties model especially volume shale (V-shale), porosity and net to gross (NTG) reservoir. The 3D properties model supported by 3D structural model, log analysis and seismic attributes could support reservoir characteristics.

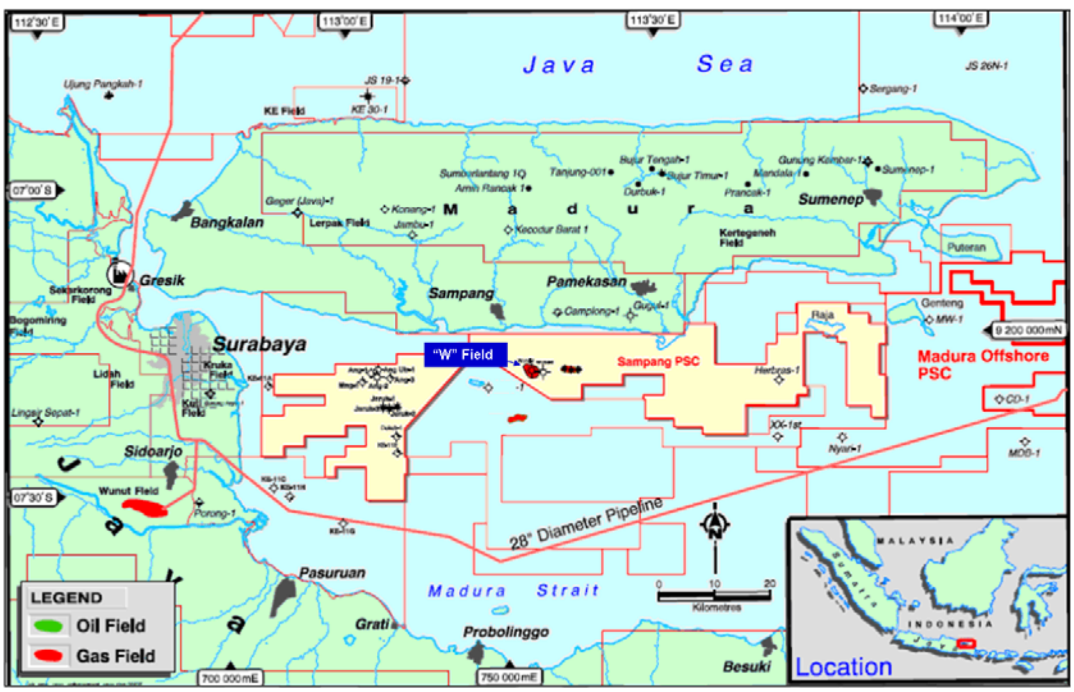

Figure 1. Study area of W-ITB Field as a gas field in Sampang PSC of Madura Strait (courtesy Santos Pty. Ltd.)

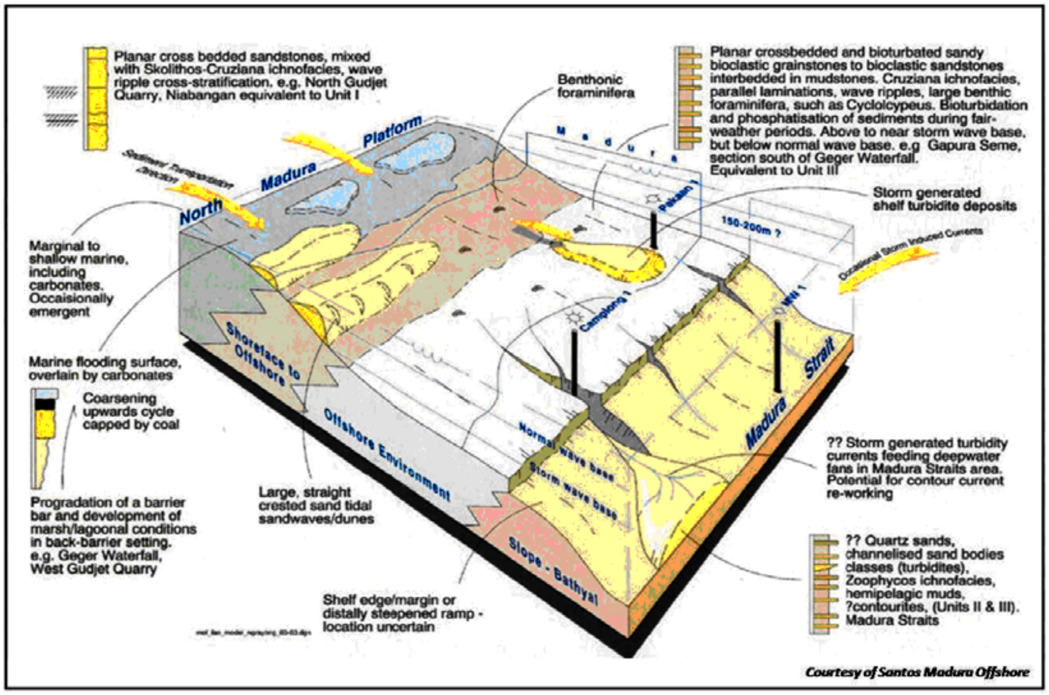

Figure 2. Deposition model of the Middle Miocene Ngrayong sediments from the North Madura Platform to the Madura Strait including depositional environments/facies from nearshore to bathyal. Wells Camplong-1 and Pakaan-1 are now located on the uplifted Madura Island. Sedimentologic succession of each facies is indicated (Satyana and Armandita, 2004)

Depositional Setting of South Madura Sub-Basin

In the South Madura Sub-Basin, recently acquired seismic data show good reflectors at the Ngrayong equivalent level, which may relate to direct hydrocarbon indicators. Ngrayong deposition in this area is considered to be storm generated shelf turbidites and deepwater fans in slope to bathyal environments (Satyana and Armandita, 2004). The Camplong-1 well drilled on Madura Island by Shell in the 1980’s penetrated feeder channel facies in the Ngrayong. Southward into the Madura Strait, Ngrayong sands were deposited as deepwater fans in the slope area (Figure 2). The Ngrayong sandstones in this fan are considered to be composed of quartzose sands and channelized sand bodies associated with hemipelagic muds and contourites of Unit II and III.

An important aspect of the Selorejo/ Mundu play is the influence of tectonics. On a regional scale the position of the shelf-edge break and other constraints, such as the timing of the area’s various inversion structures, will affect the distribution of the reservoir. Significant deposition did not take place over the structural highs. The shelfal depositional processes focussed the accumulation of the reservoir into the lows between the highs. To be able to predict where the best quality reservoir is likely to be, an understanding the distribution of accommodation space on the shelf is needed. Good quality reservoir will be in those areas where accommodation space was available during the Early – Mid Pliocene.

The key sequence boundary is top of Lower Mundu.

Top of Lower Mundu had a significant impact on the evolution of the Mundu-Selorejo depositional system. In the Early Pliocene the volume of clastic input was minimal, a carbonate platform (Karren) established itself to the immediate north and water circulation patterns on the shelf changed. The period following top of Lower Mundu represents a time when conditions were optimal for the accumulation of foraminiferal grainstones and packstones.

According to Triyana et.al., 2007, Santos geoscientists have developed a chronostratigraphic scheme for the East Java Basin based on commonly used sequence stratigraphic principles (Van Wagoner et al, 1988). This paper uses nomenclature for several chronostratigraphic units (notably the Mundu and Paciran Sequences) that are defined in that work. The geologic time scale of Gradstein et al., (2004) has been used to build the chronostratigraphic chart (Figure 3).

On the basis of geological outcrops supported by core description and laboratory evaluations it was envisaged that the Pliocene productive Globigerinid-sand has been deposited on the shelf, slope and deep floor settings of the NE-Java Basin (Sutadiwiria and Prasetyo, 2006). David M. Schiller et.al (1994) noted that at least two distinct types of Globigerinid sand deposits are documented i.e.: planktonic foraminifera sand “drift” deposited by bottom currents and less pervasive planktonic “turbidite” deposited as submarine channel-fills and fans.

METHODS

To determine reservoir characteristics both distribution and quality of W-ITB field, 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 subset of possible interrogations (Tyson and Math, 2009)

Building 3D static geological models for W-ITB Field incorporating 2D interpretation both horizons and faults, petrophysical interpretation of well W1 and stratigraphic subdivision of W- ITB#1 to W- ITB#2 Wells. 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 W-ITB Field.

In determining reservoir properties, the integrated process between well logs and core test interpretation include Repeat Formation Test (RFT), Drill Steam Test (DST) cutting, X-Ray Diffraction (XRD) and the core routine should be done to calibrate the validity of log derived reservoir properties is carried out by means of Geoscience Software and Petrophysics – Petrel. 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 and net porosity logs 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 following well data are upscaled i.e: V-Shale and net-porosity. Upscaling to an

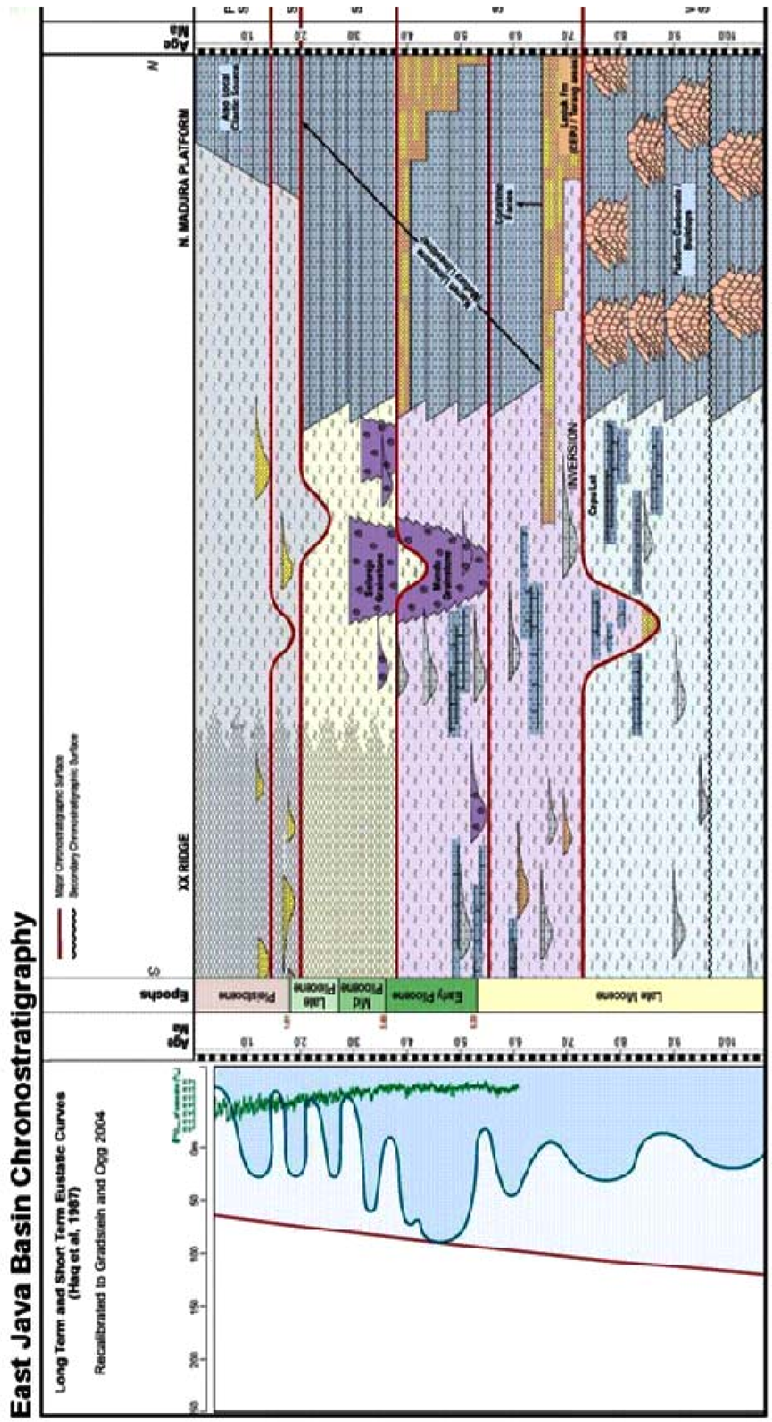

Figure 3. Stratigraphic column of East Java Basin from Late Miocene to Pleistocene (Triyana, et.al., 2007)

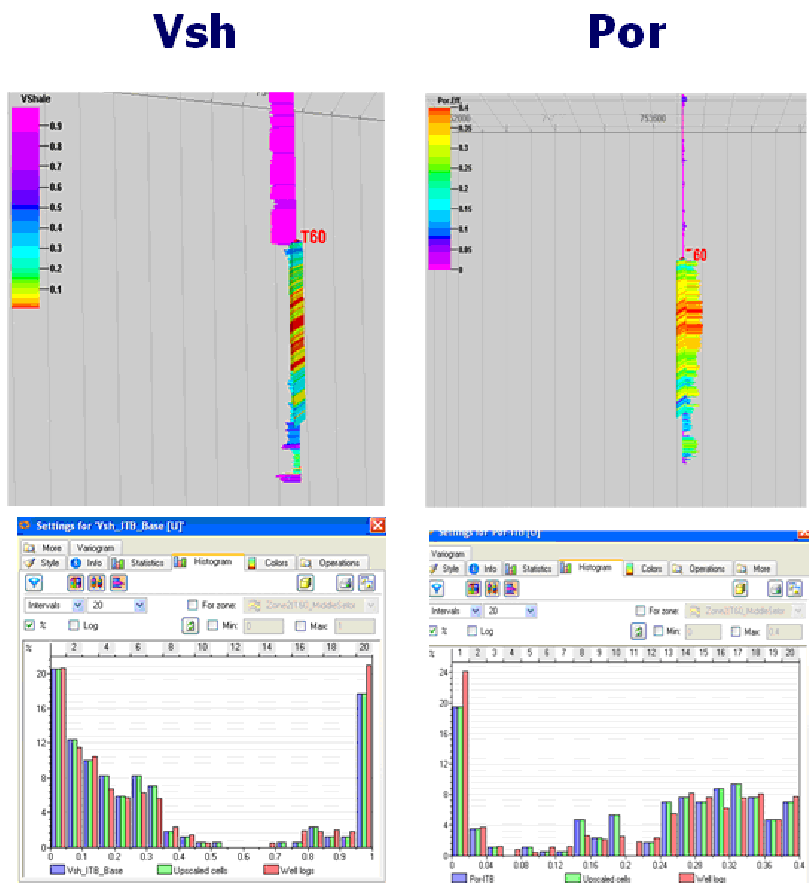

Figure 4. Upscalling W-1 well log data of V-shale and porosity

average layer thickness of 2 m has effectively captured the logs heterogeneity. The upscaled log values corresponding well with input log curves can be seen in histogram (Figure 4).

RESULT AND DISCUSSION

In W-ITB Field the reservoir facies is equivalent to Oyong field to the east i.e. Globigerina rich packstones and grainstones. This reservoir is currently producing gas from the Maleo field in the Madura Offshore PSC and oil from Oyong Field. This reservoir facies represents one of the primary exploration targets in the area. The Mundu and Selorejo reservoirs are unique due to the very high content of Globigerina tests (a type of foraminifera) include a foraminiferal limestone and deposited in an outer shelf to upper bathyal setting. Based on biostratigraphic correlation and analysis of W-ITB#1 and W- ITB#2 wells, there is missing zone in W- ITB#2 represented as an Unconformity/Hiatus.

Lateral Facies Variations and Erosional Surfaces

The section above dealt with the depositional processes associated with the reservoir. However it is very important to understand the sequence of events that led to

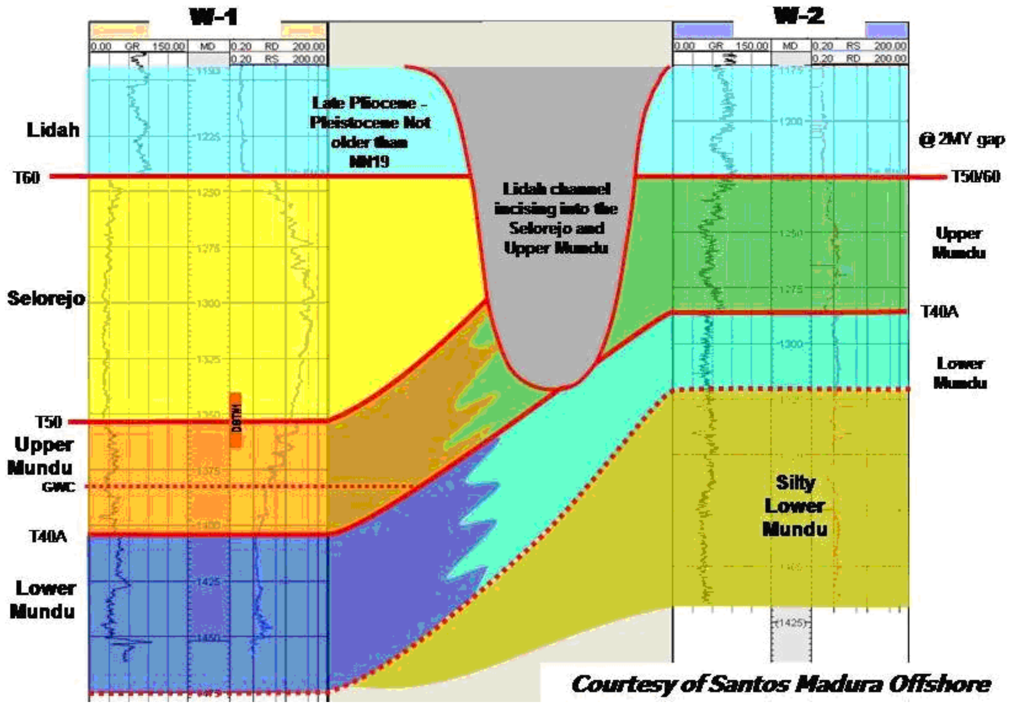

Figure 5. W-1 and W-2 wells correlation indicate Lidah Fm. Channel incising into the Selorejo and Upper Mundu Fm.

the present day structural/stratigraphic configuration in the W-ITB Field area. For instance, the Upper Mundu in W-ITB#1 contains foraminiferal grainstones whilst the time equivalent a kilometre away at W- ITB#2 is calcareous clay.

The Selorejo/Mundu interval in W- ITB#1 is dominated by foraminiferal limestone with the only variation represented by calcareous claystone in the bottom most of 15 m. In contrast the W- ITB#2 has a complete absence of Selorejo aged limestone and the Mundu is described as a claystone throughout the well. A correlatable equivalent is not present in W-ITB#1. Lateral facies changes in the Selorejo are hard to predict with only one well penetration.

The depositional model suggests the greatest thickness of Selorejo sediments accumulated in the W- ITB#1 area, thinning to the east. One could speculate that lithological changes accompany the easterly thinning, but this cannot be confirmed at present. Note the intra Lidah channel has completely eroded the Selorejo and part of the Upper Mundu formation in the area between W- ITB#1 and W- ITB#2 (Figure 5).

3D Properties Modelling of W-ITB Field

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 Acoustic Impedance (AI) that ensures the modelled property having a normal distribution that honours the input data. This is often applied in areas with sparse well control.

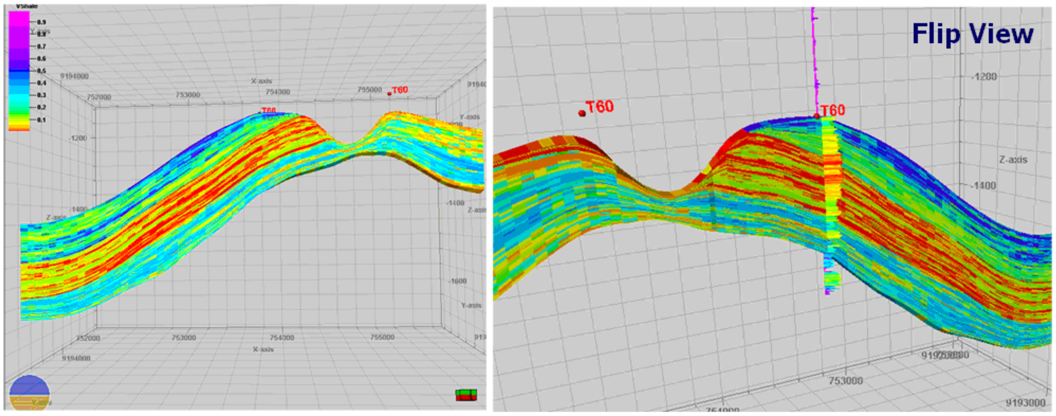

Figure 6. V-Shale distribution after upscalling well

V-shale, porosity and permeability properties were created for the whole model.

V-Shale Distribution Modeling

The V-Sh distribution using scale up V-sh log of W-ITB#1 and Sequential Gaussian Simulation with Co-Kriging of AI secondary variable. The result indicates that zone-2 and zone-3 are good quality reservoirs with V-sh value ranges 0 – 15% (figure 6). These zones have low values of v-shale indicating good to excellent reservoirs. According to laterally distribution, V-sh value of south-western area of W-ITB#1 well is lower than others. It indicates that this area has a better reservoir quality (Figure 7).

Porosity Distribution Modeling

Porosity distribution used scale up Phi-log of W-ITB#1 and Sequential Gaussian Simulation with Co-Kriging of AI secondary variable. The result indicates that zone-1 and zone-2 are good quality reservoirs with porosity ranges between 29 – 35% but Zone-1 and 4 are poor quality reservoirs. Related to laterally distribution, porosity value of the western area of W-ITB#1 well in Zone-1 has throughout good to excellent with the range between 30 – 35%. The reservoir in the Zone-2, southwestern to the northeastern part of the area is better than other areas with the ranges porosity 28 – 34% (Figure 8).

Net to Gross (NTG) Modeling

NTG Distribution used Boolean Logic in calculator with Cut-off V-Sh 37%, Porosity with three categories (High:16.2%, Mid: 18%, Low: 22%) and cut-off Sw 70% (Figure 7). The result indicates that zone-2 and zone-3 are good quality reservoirs but Zone-1 and 4 are poor quality reservoirs. The Red colour area is reservoir zone but the purple area is non-reservoir zone (Figure 9).

CONCLUSION

Gas bearing formation in W-ITB Field belongs to Selorejo and Mundu formations of Late Miocene to Late Pliocene ages. The Mundu and Selorejo formations both consist of planktonic foraminifera of wackestone to grainstone facies deposited in outer neritic to upper-bathyal setting. Based on petrophysical analysis, the reservoir interval can be devided

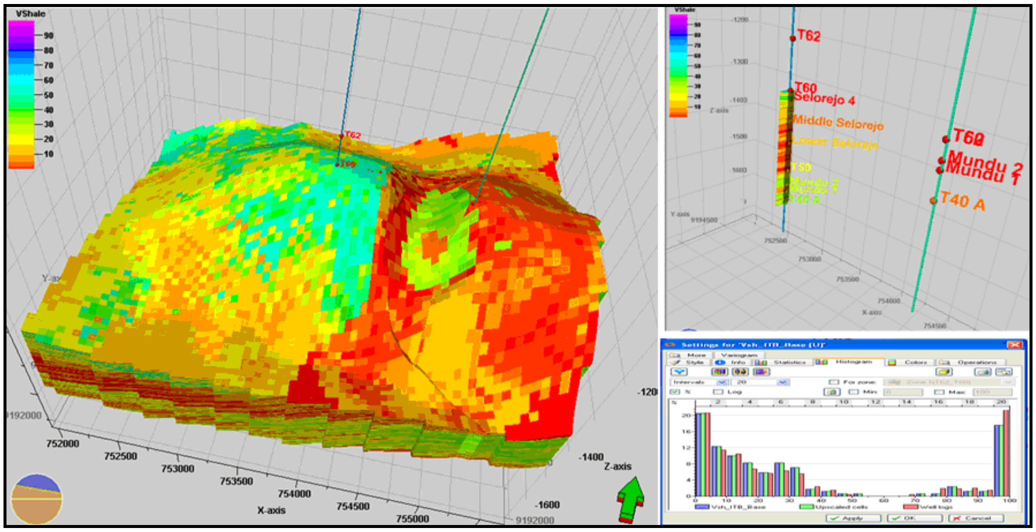

Figure 7. 3D Modeling of V-sh distribution

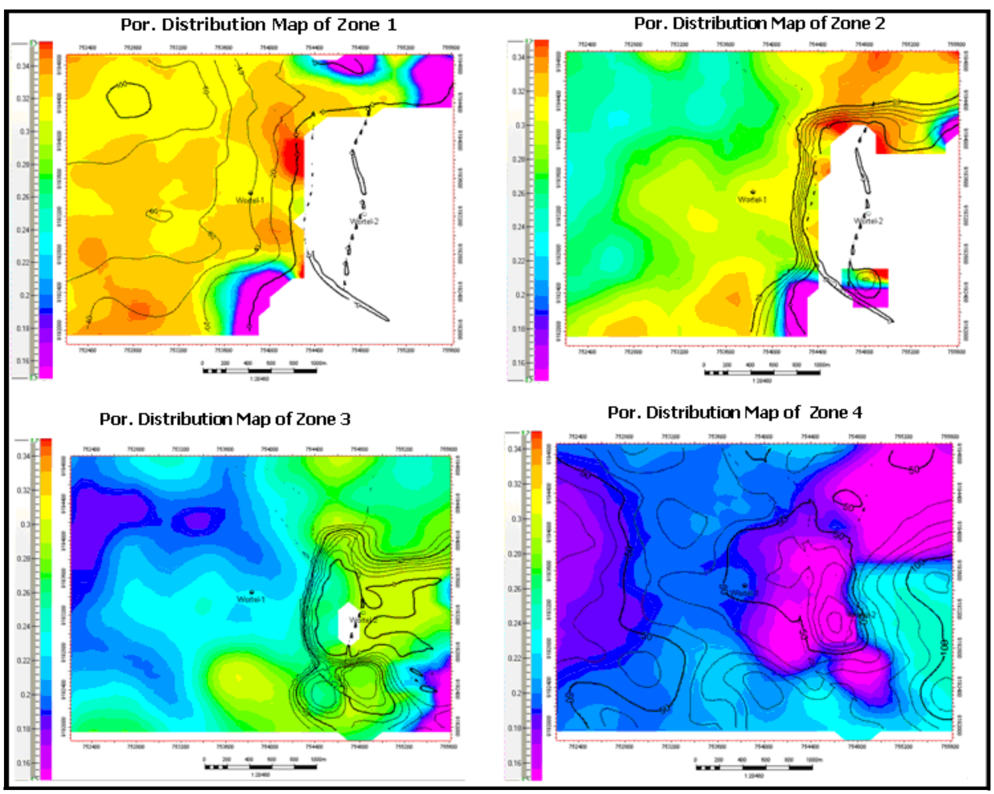

Figure 8. Porosity distribution of four zones showing Zone-1 is the best reservoir

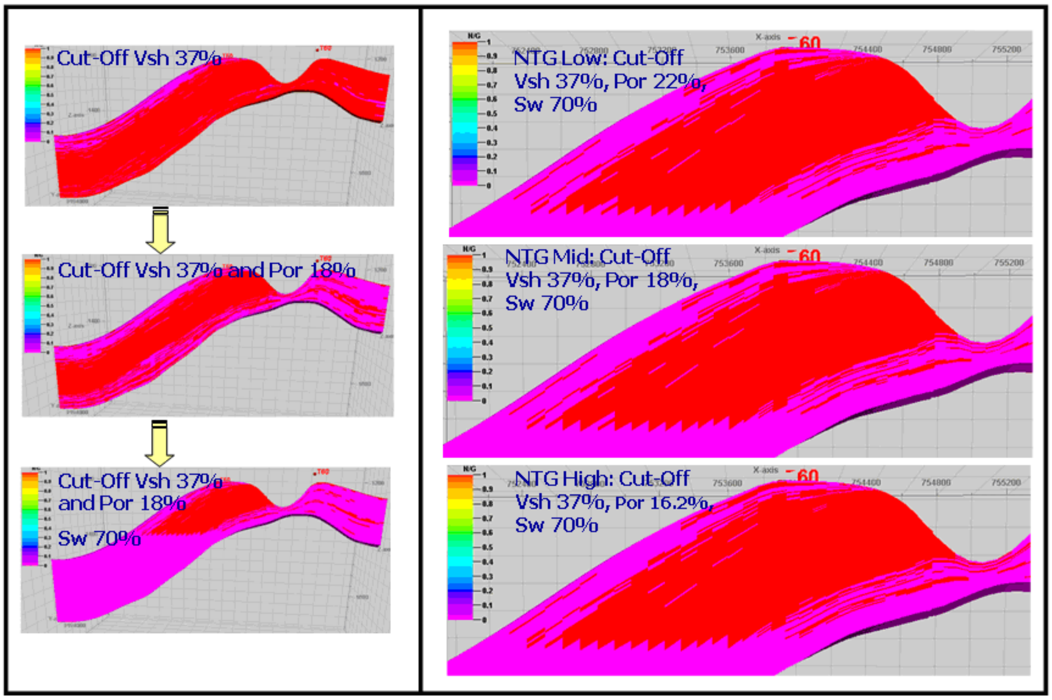

Figure 9. Porosity distribution of four zones showing Zone-1 is the best reservoir

into four zones respectively top to bottom; Zone-1, Zone-2, Zone-3 and Zone-4

Based on 3D properties modeling, the best reservoir quality of W-ITB Field is correspond to Zone-2 and Zone-3 while Zone-1 and Zone-4 have relatively poor reservoir quality. The Gas trap in the W-ITB Field is related to combination of anticlinal and faults structure combine with stratigraphic traps related to deep-channeling of the Lidah shaly formation.

For V-sh vertically distribution, Zone-2 and Zone-3 are good quality reservoirs ranging from 0 – 15%. As laterally distribution, south-western area is better reservoir. As for porosity distribution, zone-1 and zone-2 are good quality reservoirs range 29 – 35% but Zone-1 and 4 are poor quality reservoir. Related to laterally distribution, porosity value of western area of W-ITB#1 well in Zone-1 has throughout good to excellent ranging between 30 – 35%. The NTG result indicates that Zone-2 and Zone-3 are good quality reservoirs.

Since the reservoir properties are derived only from W-ITB#1 well, there is some uncertainty in the lateral distribution of the properties away from the well control. Seismic Acoustic Impedance (AI) data have therefore been used to help constrain the porosity distribution.

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