Application of Structual Uncertainties in Quantifying Prospectivity and Reducing Drilling Risk in Frontier Area : Babar Selaru, Eastern Indonesia

Anky Fatwa
INPEX Masela

Lisnanda Alam Perdana
INPEX Babar Selaru Ltd

Afif Saputra
INPEX CORPORATION

Ade Himsari
INPEX CORPORATION

PROCEEDINGS
JOINT CONVENTION YOGYAKARTA 2019, HAGI – IAGI – IAFMI- IATMI (JCY 2019)
Tentrem Hotel, Yogyakarta, November 25th – 28th, 2019

Application of Structural Uncertainties in Quantifying Prospectivity and Reducing Drilling Risk in Frontier Area : Babar Selaru, Eastern Indonesia.

Anky Fatwa; H. Banjarnahor*; Keiji Nihei*; Lisnanda AP*; Afif Saputra*; Ade Himsari*; Ian Arthur Kainama**;*
**INPEX Babar Selaru Ltd.*
*** Schlumberger – Software Integrated Solutions*

Abstract

Stuctural uncertainties have a direct impact in exploration, development, and production, especially in the frontier area, such as Babar Selaru PSC, located in the Timor-Tanimbar Trough in the Eastern Indonesia. The block is located around 40km north from the nearest wells, the water depth of the block ranges from 300m to over 3,000m.
One of the target in this block is Jurassic sandstone play (structual-stratigraphic trap) which was identified by the high resolution broad band 3D seismic data. However, the Jurassic section is under the detachment and Cenozoic overburden is intensively deformed by thrust movement. This complicated geological settings makes it difficult to consutruct a robust velocity model when there is no well for depth control in and around the block.
PSDM seismic velocity also gives us challenging result due to the succession of thick carbonate which possible affect to the below structure. Usually seismic imaging depth is few percent deeper than true vertical depth in case of clastics overburden because of micro-anisotropy and/or layering effeects, especially in shale section, however the opposite effect between seismic imaging depth and true vertical depth is observed in general if there is thick carbonate. So, it is very difficult to estimate the true vertical depth from seismic imaging depth in the Babar Selaru block.
This paper present a number of probabilistic scenarios involving several process such as Velocity Modeling and Horizon Modeling to assess the uncertainty range of the trap size. The effects on each process of the GRV calculation were observed and analyzed, to understand which process has greatest influence on the result.

Introduction

The Babar Selaru block is located in the Timor-Tanimbar Trough, which lies between passive margin tectonics of Australian plate in the south and active margin tectonic of the Banda Outer Arc in the north, in the Arafura Sea in the Eastern Indonesia (Figure 1). The block is located approximately 100 km southwest of Saumlaki, Yamdena Island in the Tanimbar Archipelago and 40 km north from the nearest wells. The water depth of the block range from 300m to cover 3,000m and the exploration leads locates in the range of 300m – 2,300m water depth. The latest area of the block is 1,634km2 (Figure 2) after 20% retained of 2nd relinquishment of the original block at the end of 6th contract year, covering all of the Jurassic prospect/leads and curved out non-prospective areas and mostly covered by 3D broadband data. Geology in Babar Selaru block comprises of northern extension of Australian geology with north dipping normal faulth in the south, and thrust complex geology (Banda Allocthon) in the north. Detachment divides both geology, detachment cut accross Cenozoic in south (Babar Selaru block). However, detachment lies more deeper in the north and cut across Mesozoic. Thus Mesozoic cut by detachment is uplifted and exposed, observed in Timor, Babar and Tanimbar Island.

We believe that is one of the challenging for the origin of the Banda Arch, the complex thrust area due to collision between Australian plate and Eurasian plate. That is why we choose 3D Broadband seismic rather than 3D convensional seismic because 3D Broadband seismic provides better recovery of seismic energy from deep section and contributes to increasing understanding of petroleum system and risk element of exploration target in a frontier area. Detail velocity modeling with PrSDM also provided better resolution and continuity of seismic images under thrust complexes and large fault surfaces by overcoming the poor illumination issues. The seimic inversion result from 3D Broadband data still remain the uncertainty of lithology prediction caused by very low frequency model for the deep target in Jurassic sandstone play, although Broadband data reduce the bias of initial model during seismic inversion. Anyway, we brought the latest technology to Indonesia to accelerate the Deep Water Exploration. Total 3259km2 Broadband 3D seismic survey covering the central part of the block was acquired in Q1 2013 as one of the firm commitment works of first 3 years exploration of PSC in order to tackle the lack of illumination under imbricate thrust deformation then to reveal the hidden geology in the thrus complex.

Our target in Babar Selaru area is Jurassic sandstone formation same as with the nearest proven field. This formation traps in our area are defined by structural interpretation used by 3D Broadband seismic data, but the Jurassic sandstones formation traps are located beneath the fold thrust belt or complex structure area in the northern part of Babar Selaru block and no reference well around except for 40km the nearest well to Babar Selaru block or 70km to our prospect and leads. That is way we think there remain concern that above fold thrus belt and thick carbonate succession affect to our 3D Broadband seismic velocity and shape of Jurassic sandstones play traps. Therefore, we plans to carry out seismic velocity modeling review to verify uncertainty of 3D Broadband seismic velocity and shape of Jurassic play traps. The method describes in this study address the advantage of creating multiple probabilistic maps derived from 3D Broadband seismic velocity as a base case added by possible error maps. This makes it particularly suitable for optimized GRV distribution range for the input of probablistic volume calculation derived from the structural uncertainty analysis and reducing drilling risk in the frontier and complex structural area.

Data and Method

3D Broadband seismic data has capabilities to provide better recovery of seismic energy and 3D velocity modeling from PSDM also provide better resolution and continuity of seismic image under the thrust compex area, that is why we conduct the seismic intepretation using these data to identify prospects & leads, and this depth structure map and 3D PSDM velocity are taken as a base case for analyzing the structural uncertainty. Although we have 3D Broadband seismic data, but there is still uncertainty in depth structure map due to fold thrust belt or complex sturcture, thick carbonate succession, seismic processing, such as deconvolution, stacking, migration, etc, seismic picking or interpretation, time-depth conversion, geological uncertainty, such as thickness, trends, well corelation etc. So, we conduct this study to verify the uncertainty of this base case depth structure map and 3D seismic velocity. In this study we also use regional 2D seismic velocity data, layer cake velocity modeling, and 3D seismic velocity from surrounding proven field to compare the depth converted map with 3D Broadband PSDM seismic velocity together with well formation tops of the top reservoir.

In this study, we create the error surfaces that will be added to the base case surface. Some studies about the structural uncertainty usually using well information, and use Sequential Gaussian Simulation algorithm to stochastic error surface, So they will create essentially zero at the well locations, varies smoothly away from the wells, variance depends on the quality of the seismic and the distance from the wells, but in this study we don't have any well information. So we just create error surfaces based on standard deviation 40 and max/min output data range is +/- 100m, this values is coming from testing from several velocity modeling methodology such as Layer Cake Model, regional 2D seismic velocity, and 3D seismic velocty in surrounding proven field. Set up velocity model using layer cake model is starting from MSL to seabed and continue to the base of Jurassic sandstone formation and shows the difference between depth structure with well top less than 50 m and also identified three prospects and leads. Set up velocity modeling using 2D regional seismic velocity and create around 128m discrepency between well tops and depth structure map. The last one is using 3D seimic velocity from surrounding proven well, this velocity was shooted from 3D convetional seismic. The depth conversion using this velocity states that the maximum discrepency is around 208m. Looking to the varios results, we decided to use standard deviation 40 from combination velocity modeling between 3D conventional seismic velocity from Seabed to the Top of Cretaceous and contant velocity model from Top of Cretaceous to the base of Jurassic sandstone formation. We also test the effect of Variogram setting, using small range and large range. We also test the effect of standard deviation to get the good result. Looking to the various result from several depth conversion method and testing parameter, there are still uncertainties of discrepency between depth structure map and well tops, so we put the output data range around min/max 100m.

After testing several parameters, we start to design the structural uncertainties workflow in petrel (Figure 3). First, we have to create the error surfaces 100 maps with standard deviation and maximum output data range as explained above (line 13) and search the lowest closing contour until 100m below the crest depth for each maps (100 maps) at line 19, after that we calculate the GRV. Several Depth map result from 5 iteration is showing several lowest closing contour (Figure 4 & 5). In this study we run 100 iteration to get 100 maps as a results and we can calculate the GRV of each map automatically.

Result and Discussion

Several map from 100 maps showing good potensial GRV in some crest point area, but in this area we have several crest point (Figure 6), so we decided to run 100 iteration for each crest point area and calculate the GRV of each map. The placement of the crest point is still provides eratic results, varies and without definite pattern, so that is why we think that the placement of the crest point is no longer a problem and can select any scenarion for the production and compare the GRV. The current 4 (four) scenarios from crest point is considered to be acceptable, though some realization didn't create closure around that crest points (Figure 7-10).

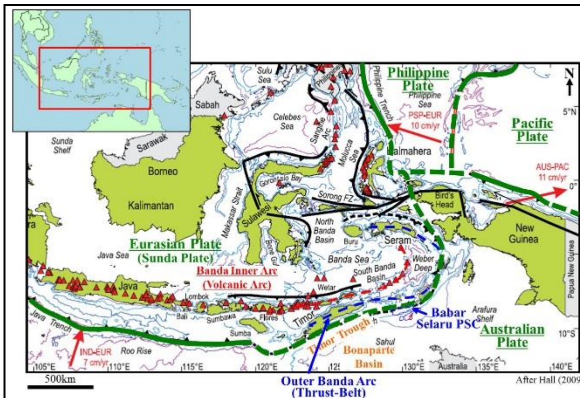

Figure 1: Geography of east Indonesia and surrounding regions, after Hall (2009). Babar Selaru PSC is located on the Timor-Tanimbar Trough which lies between passive margin tectonics of Australian plate in the south and active margin tectonics of Outer Banda Arc in north, in the Arafura Sea in the Eastern Indonesia.

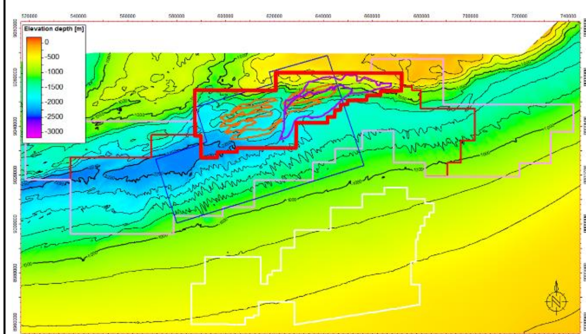

Figure 2: Babar Selaru PSC block after 20% retained of 2nd Partial relinquishment of the original block at the end of 6th contract year, covering all of the Jurassic prospects/leads and curved out non-prospective areas and mostly covered by 3D Seismic.

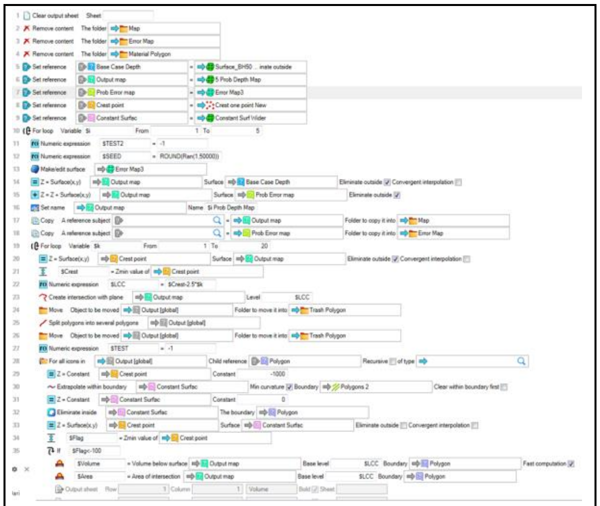

Figure 3: The structural uncertainties workflow in petrel. Starting from creating the error surfaces (line 13) and searching the lowest closing contour (line 19) until 100m (=40x2.5m) below the crest depth.

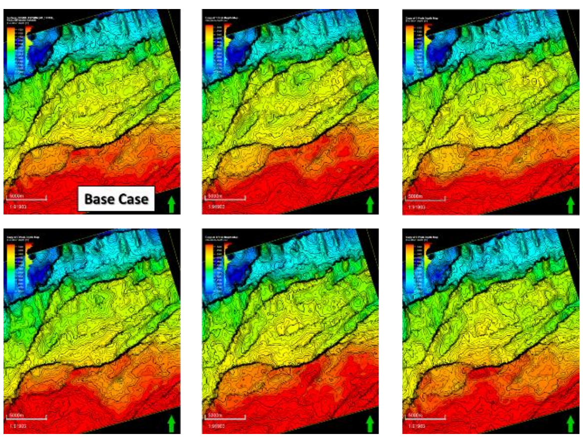

Figure 4: Example of depth map result from 5 iteration is showing several lowest closing contour.

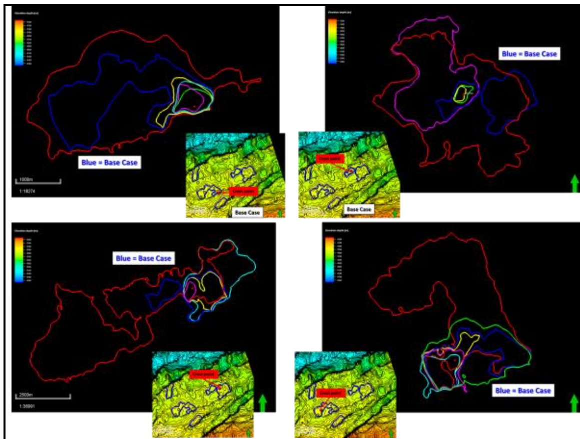

Figure 5: The Lowest Closing Contour from each scenario result determined from 5 iteration structural uncertainties workflow.

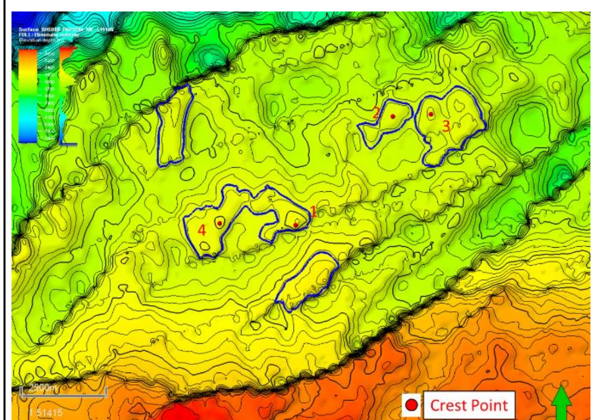

Figure 6: Depth structure map with showing some several crest point inside prospect area. In order to calculate the uncertainty of 4 way dip closure, we selected 4 points, honoring the crests of the dominant closures observed in the base case map.

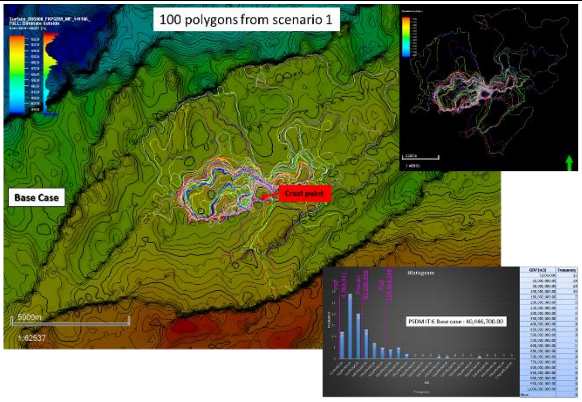

Figure 7: Result of scenario 1 with 100 iteration and Lowest Closing Contour. Pmean GRV is around 83 meter cubic.

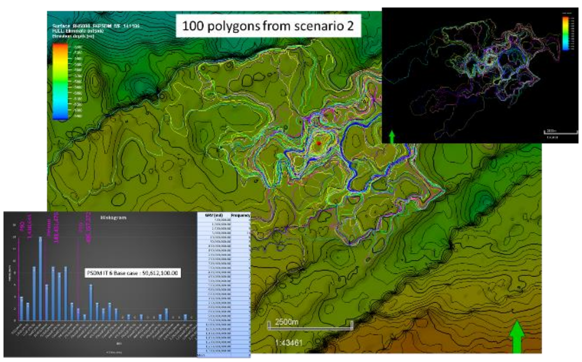

Figure 8: Result of scenario 2 with 100 iteration and Lowest Closing Contour. Pmean GRV is around 148 meter cubic.

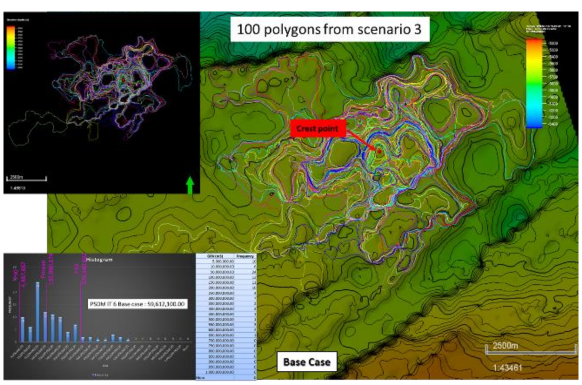

Figure 9: Result of scenario 3 with 100 iteration and Lowest Closing Contour. Pmean GRV is around 132 meter cubic.

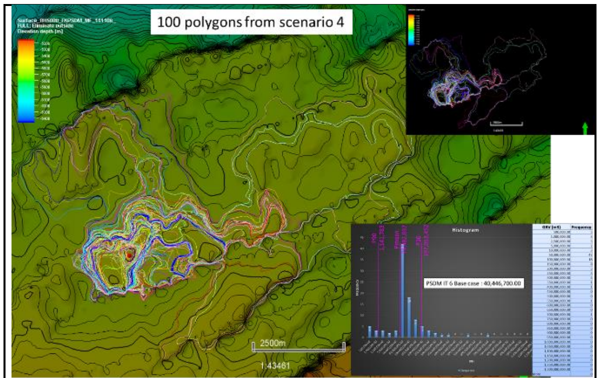

Figure 10: Result of scenario 4 with 100 iteration and Lowest Closing Contour. Pmean GRV is around 74 meter cubic.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	GRV(m3)	GRV(m3)	GRV(m3)	GRV(m3)
P10	225,463,598	495,157,372	370,340,842	197,053,452
Pmean	82,230,356	148,431,476	132,860,174	74,482,037
P90	4,783,911	1,430,645	4,487,887	1,141,783
Base Case	40,446,700	59,612,100	59,612,100	40,446,700

Figure 11: Comparison for each 4 way dip closure of our prospect. The maximum GRV for this comparison is 150m3.

Conclusions

In this study we evaluated the range of structural uncertainties and range of GRV uncertainties for the 4 way dip closure of our prospects and leads. The maximum GRV for this case study is around 150 m3 which we can continue to calculate the reserved then we can decided which prospect and lead has the biggest reserved to be drilled (Figure 11).

References

Hall, R. [2009] Hydrocarbon basins in SE Asia: Understanding why they are there. Petroleum Geoscience, 15, 2References here is really your

Fujimoto, M., Guo, Y., Fatwa, A., Sasaki Y., 2014, IPA14-G-122, Proceedings Indonesian Petroleum Association, 38th Annual Convention and Exhibition.
Hall, R., 2009, Petroleum Geoscience, 15, 2

Acknowledgements (Optional)

The authors thank INPEX and Pertamina Hulu Energi for the permissions to publish the paper. Alwo we would like to thank Schlumberger – SIS for their effort of solutions.