Hydrocarbon Accumulation Uncertainty in Miocene Carbonate Build-Ups, NEJB*

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Abstract

Miocene Carbonate Build-up of JS-1 Ridge Structure, also well-known as Kujung-1 Reef, is one of the prolific reservoirs in the North East Java Basin (NEJB). It developed as facies of carbonate platform, which is inhabited by growth of localized carbonate build-ups, with some amalgamated into wider build-ups. It is characterized by up to 1000 feet vertical thickness but often of small areal extent (< 1 km^2). The JS-1 Ridge structure is bounded by two proven hydrocarbon kitchens i.e. East Bawean Trough and Central Depression. Patch reef geometry mostly presents as 4-way dip stratigraphic closure, while amalgamated reef geometry may be present as 4-way dip stratigraphic closure or 3-way dip structural-stratigraphic (combination) closure.

Repeated exposure associated with sea level change is responsible for good reservoir properties among the facies throughout the area. Carbonate growth which was controlled by marine diagenetic environment in eugenic stage, actually generated cycles of tight-porous interval. It resulted in rock properties variation within the facies, with 200-300 feet thickness of tight-dominated zone mostly occurs at the top part and shifts into porous-dominated zone up to bottom part. It can be concluded that there will be almost no exploration risk from the aspect of reservoir component.

However, the main issue in exploring these individual closures is hydrocarbon accumulation variation among them. The hydrocarbon accumulation variation can be quite extreme in some localities, as dry reef surrounded by HC-filled reefs and vice versa. This condition might be due to complex geological processes, which is represented by five petroleum system components, i.e. source rock, timing/migration, reservoir, closure, and containment. Assessment of each component has been carried out to

investigate the causes of failure that might occur and concluded that most-likely components responsible for this condition are timing/migration and containment.

Several analyses regarding hydrocarbon accumulation prediction in these carbonate build-ups have been done, i.e. fault presence analysis related to possible spill/leak point, hydrocarbon migration analysis using basin modeling, and seismic HC prediction (AVO/Lambda Rho) to directly predict level of hydrocarbon accumulation. Every method gives its respective interpretation and has possible error and uncertainty. It works in some parts of the area, but never really managed to explain this condition thoroughly to the entire area. On a map view basis, rough trends can be observed, but exact condition that may be applied for each individual closure is still difficult to be determined.

Data is mainly derived from drilling results of Miocene carbonate build-ups in JS-1 Ridge area, focused in PHE WMO northern block. Discovered hydrocarbon in-place numbers and petrophysical formation evaluation results are used as basis to observe variations among the closures. Post-drill G&G analysis is also used to analyze petroleum system components which may control distribution of HC-filled reefs and wet reefs.

Thereafter, all available numbers from HC-filled reefs to be plotted into probability charts to observe statistics which represent the population. Data preparation for analog population data and estimation job for next possible drilling outcome are done using *Toolbox* and *Multi-Method Risk Analysis* software developed by *Rose & Associates*.

Drilling results from a total 58 reefs, show there are groups of HC-filled reefs (total 38) and wet reefs (total 20), or equivalent to 65% discovery success percentage. For the group of HC-filled reefs, the statistic suggests very high variation in in-place numbers, with skewed-right shape distribution (lognormal), ranging from 0.1 to 78 MMBOE. Mode is less than 1 MMBOE, median is 4.8 MMBOE and arithmetic mean is 13.5 MMBOE. This high variation in in-place numbers is certainly due to the accompanying reservoir parameters i.e. net to gross, porosity and water saturation, which also have variations.

Different results among the closures might be due to complex geological process, which is represented by five petroleum system components, i.e. source rock, timing/migration, reservoir, closure and containment. Assessment of each component has been carried out to investigate the causes of failure that might occur and concluded that most-likely components responsible for this condition are timing/migration and containment.

Several analyses have been done to understand HC-filling patterns within the closures. Fault presence analysis was carried out to find out possible spill/leak point that occurred after successful migration. It resulted in two fault conditions: possible leaking faults that may responsible for wet reefs and confirmed sealing faults found in some producing reefs. This analysis is still ongoing to successfully distinguish the role of faults. 3D basin modeling was intended to understand hydrocarbon migration process and pattern. It is actually successful to provide regional understanding regarding principal migration pattern but still struggle to get detail pattern that can answer quite extreme variations in some localities. Another effort to predict HC accumulation is by directly observing seismic behavior using seismic AVO/Lambda Rho analysis. This analysis works in a majority of reefs but fails in some reefs. The success percentage of this analysis to predict drilled reefs using blind-test method is around 70%, or still has 30% chance of error. Every method gives its respective interpretation and has possible error and uncertainty. It works in some parts of the area, but never really managed to explain this condition thoroughly to the entire area.

On a map view basis, actually rough trends can be observed. Noticeable HC-filled trend can be found in northwestern part and wet trend in northeastern part, while southern part shows a relatively more random trend. Nevertheless, the exact condition that might be applied for each individual build-up is still difficult to be determined. Due to this condition, prospective resources estimation becomes the big issue to be handled, since it will affect further economic analysis for an exploration prospect. Over optimistic estimation may lead to financial ruin, while over pessimistic estimation may lead to loss of opportunity. Therefore, proper resources estimation is essential for better decision making.

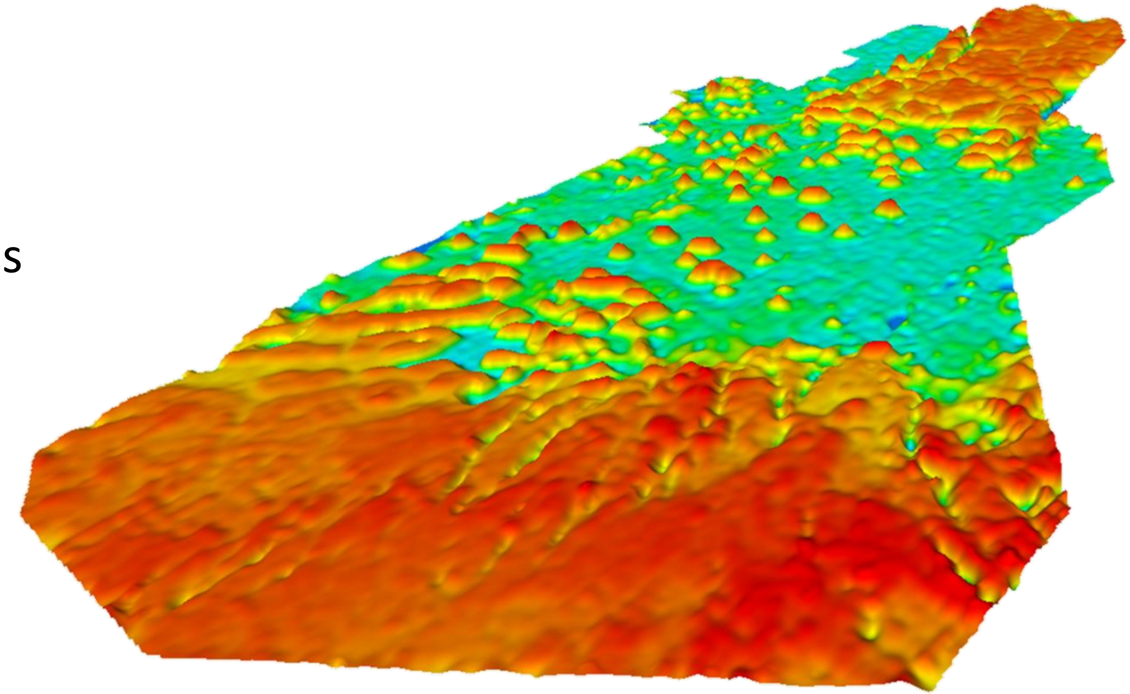
At least there are four estimating method options to do for this case: deterministic, probabilistic using distribution of entire area, probabilistic using distribution of specific trend, and probabilistic using seismic HC prediction. Deterministic method will produce single possible outcome from single parameters value, which is very difficult to be done since variability definitely happens in nature. Therefore, deterministic method is not recommended to be used. Probabilistic method is strongly suggested to be able to deal with uncertainties. Probability method using population data from the entire area can be used to accommodate all possible outcomes, but variance can be too high. This might be a safe option but gives no specific direction. Probability method using population data from specific trend is intended to reduce variance. This might give specific direction but may find pitfalls in area with extreme differences. Probability method using seismic HC prediction is also intended to reduce variance, however it really depends on the reliability of prediction accuracy. Every option has different advantages and disadvantages and may produce different character of possible outcomes. Input from advance geological and geophysical analysis is absolutely necessary to reduce variance of particular probability distribution and to improve resources estimation. The target is to reduce uncertainty as much as possible but still pay attention to highest/lowest possible outcome.

Some efforts can be done to avoid unnecessary possible outcome. Based on cross-plot analysis, some reservoir parameters may have correlation to another. Hydrocarbon column thickness may have positive correlation with net to gross value. Porosity may have negative correlation with water saturation. From fluid parameters, oil formation volume factor (Bo) may have positive correlation with solution gas yield (GOR), etc. Other efforts are like performing reality checks for map, parameters, and highest/lowest possible outcome.

Reference Cited

Satyana, A.H., and A. Darwis, 2001, Recent Significant Discoveries Within Oligo-Miocene Carbonates of the East Java Basin: Integrating the Petroleum Geology: Proceedings Indonesian Association of Geologists (IAGI) 30th Annual Convention and Geosea 10th Regional Congress, p. 42-46.

HYDROCARBON ACCUMULATION UNCERTAINTY IN MIOCENE CARBONATE BUILD-UPS, NEJB



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OUTLINE

- INTRODUCTION
- STATISTICS
- PROBLEM
- EFFORTS
- CONCLUSIONS

- INTRODUCTION
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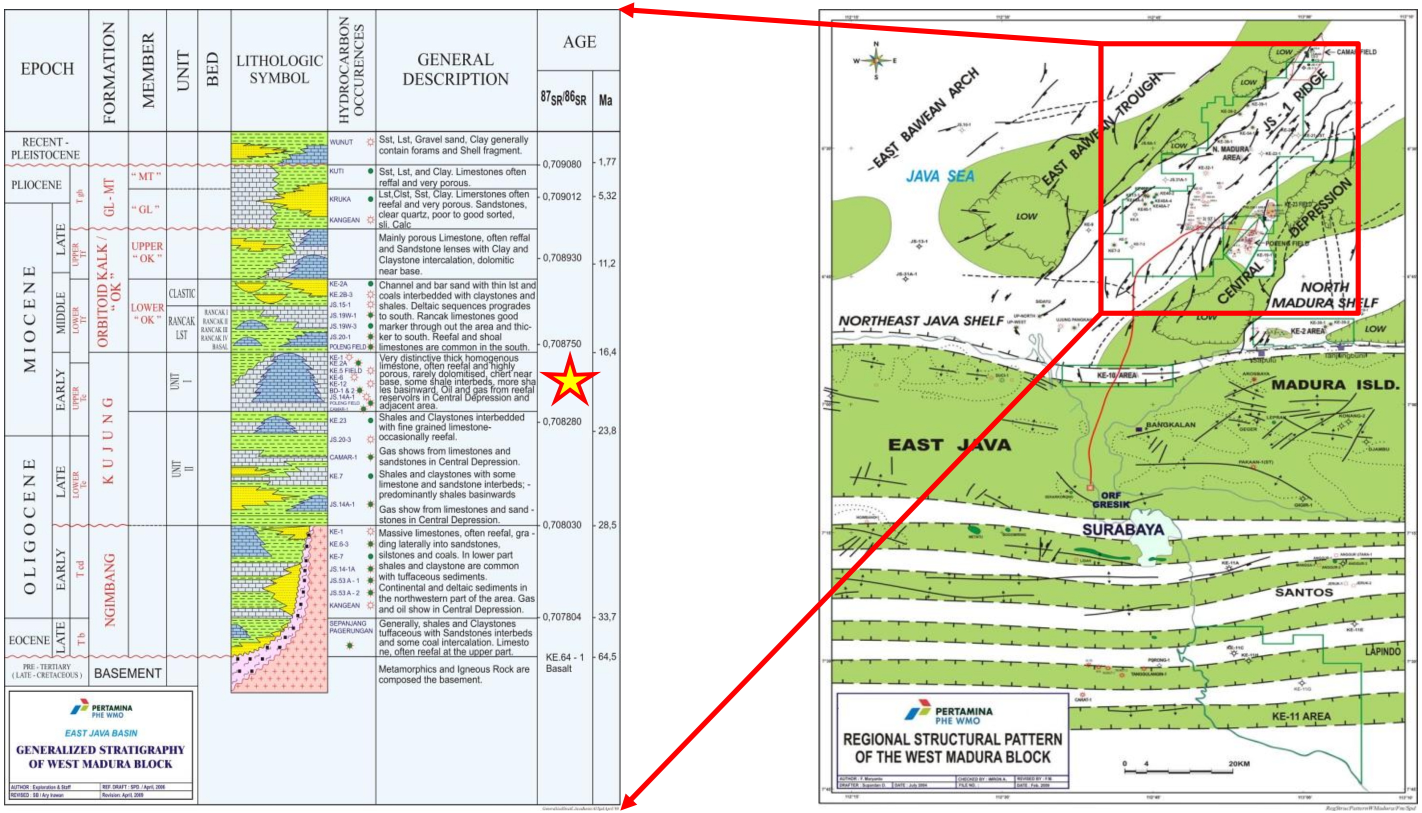
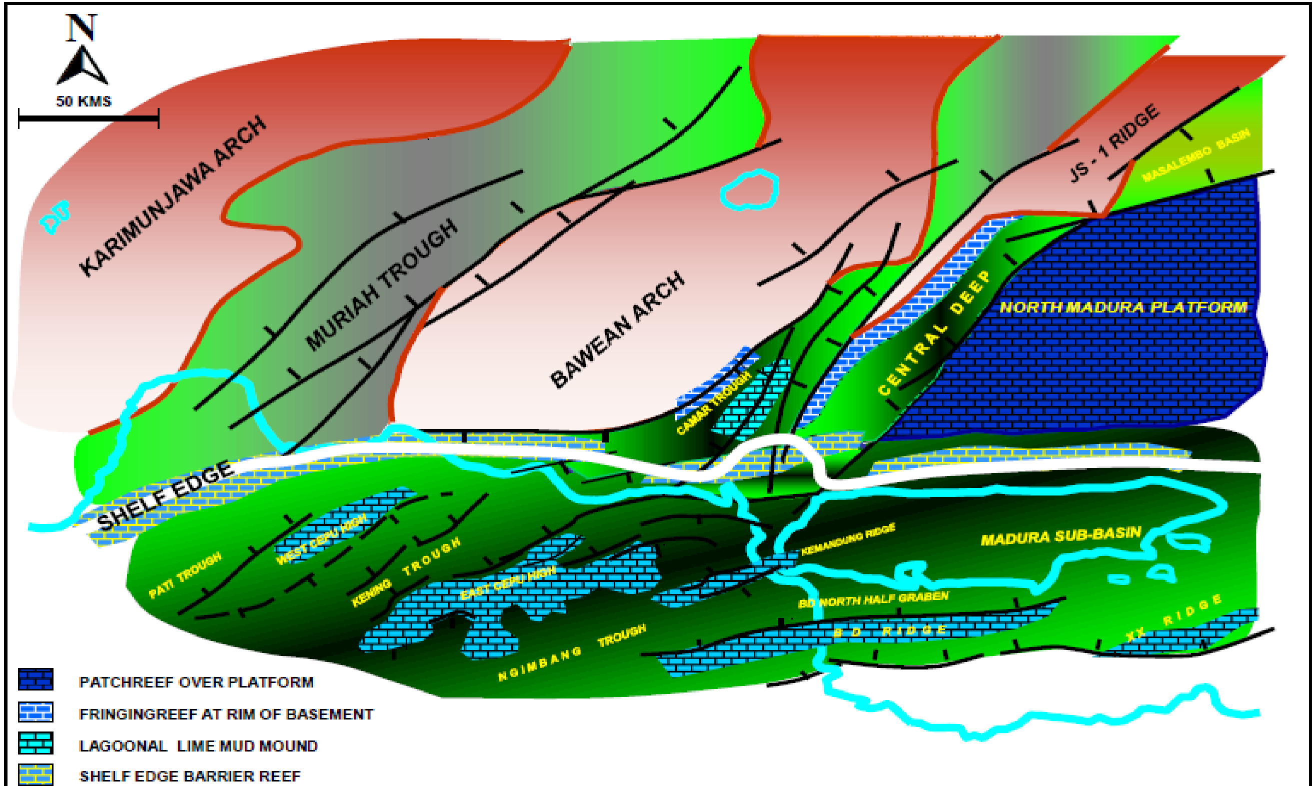
FOCUS AREA


PHE WMO Northern Block
North East Java Basin
Java Sea
Jakarta
Bogor
Bandung
Cirebon
Semarang
Surabaya
Malang
Kediri
Purwokerto
Tasikmalaya
Palembang
Banjarmasin
Makassar
Denpasar
Palangkaraya
BANTEN
WEST JAVA
CENTRAL JAVA
SPECIAL REGION OF YOGYAKARTA
BALI
WEST NUSA TENGGARA
SOUTH SUMATRA
LAMPUNG
KALIMANTAN
WEST SULAWESI
Google
Google Data SIO, NOAA, U.S. Navy, NGA, GEBCO Landsat / Copernicus Camera : 1,494 km 8°35'26"S 105°44'57"E -4,239 m 100%

REGIONAL GEOLOGY

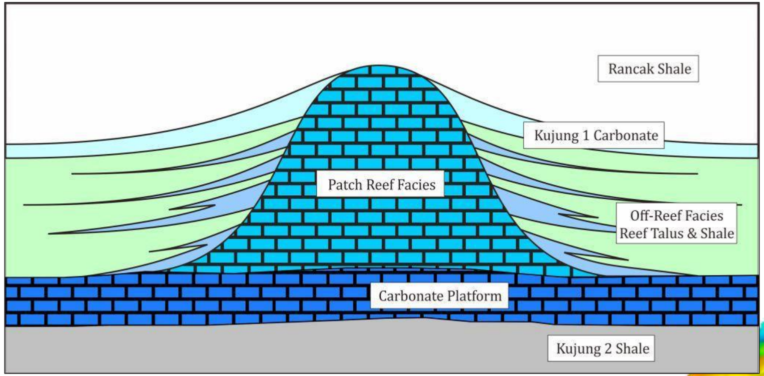


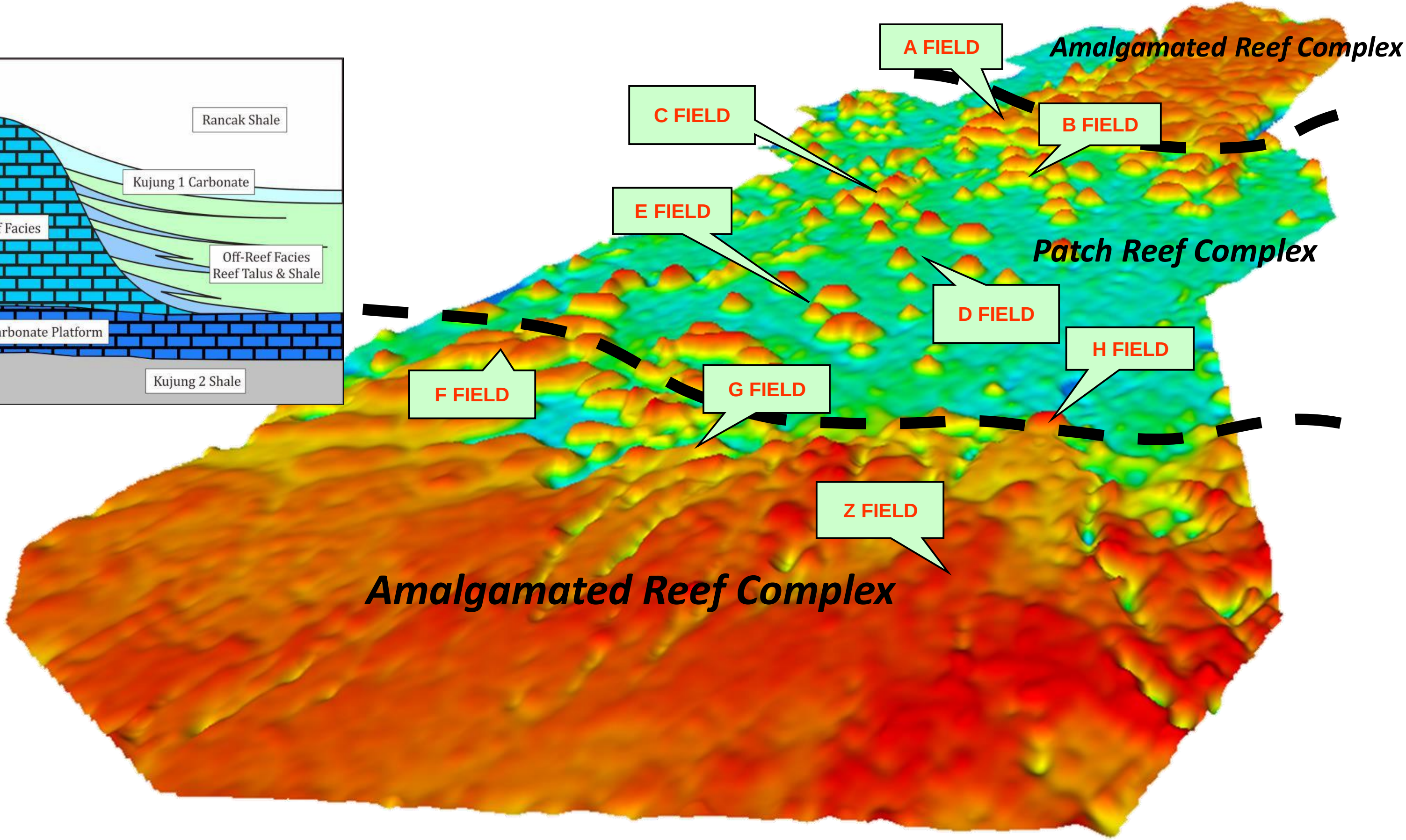
DEPOSITIONAL FACIES OF OLIGO-MIOCENE CARBONATES



Satyana and Darwis (2001)

CARBONATE BUILD-UP - KUJUNG FORMATION





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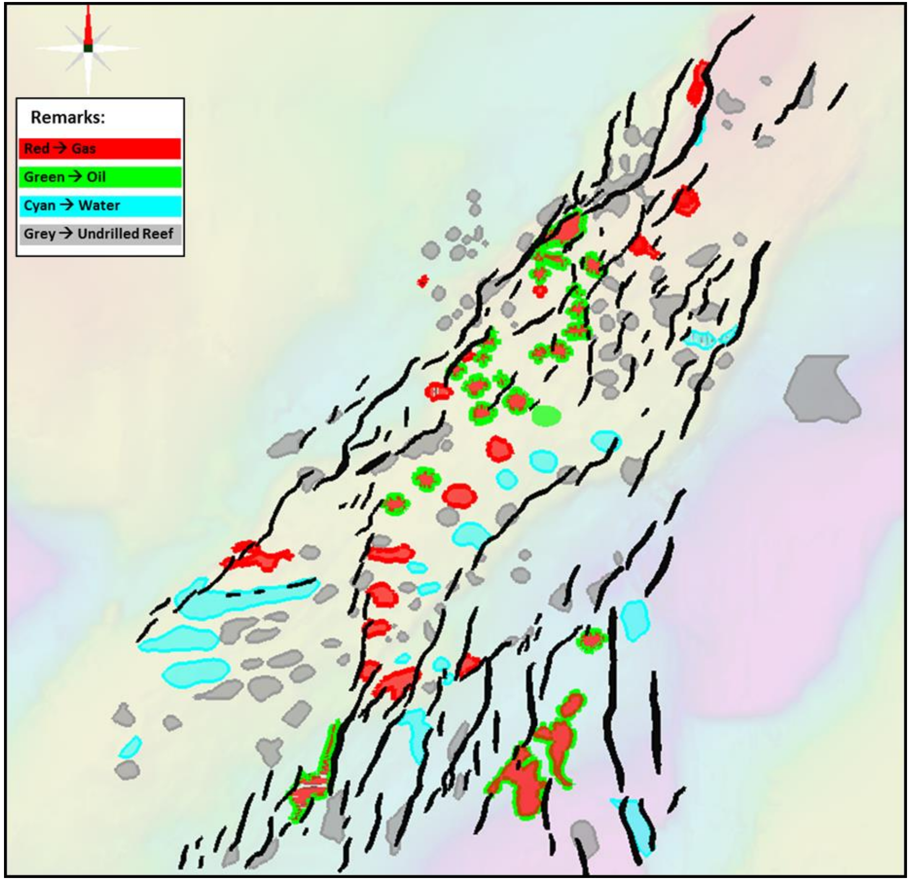
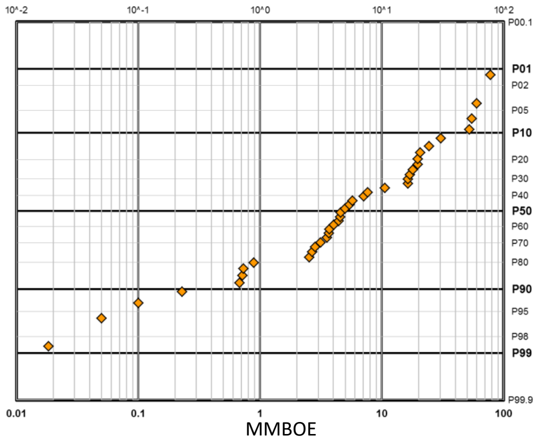
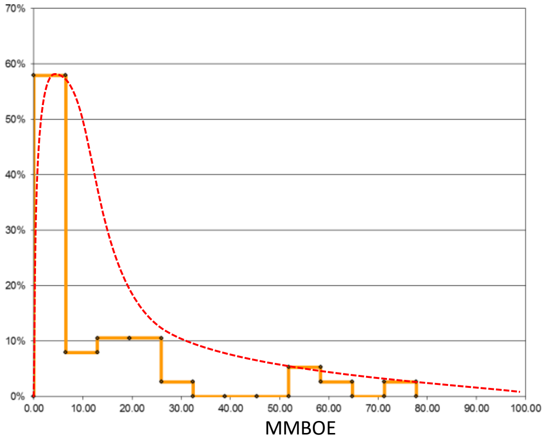
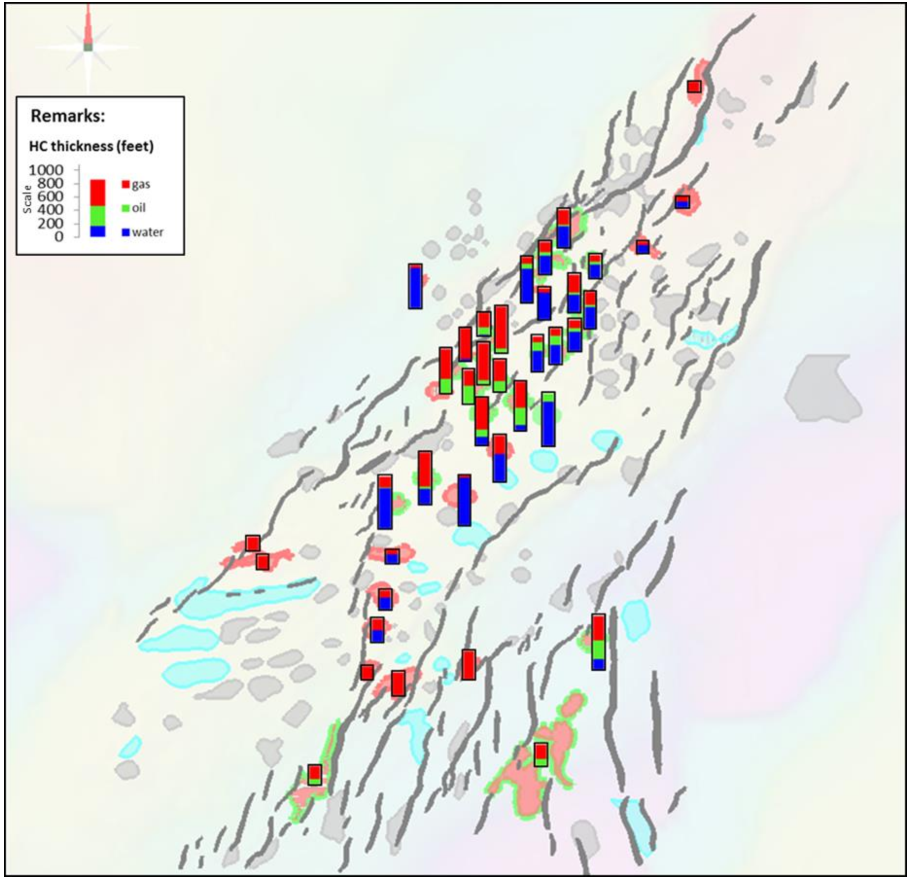
HYDROCARBON ACCUMULATION

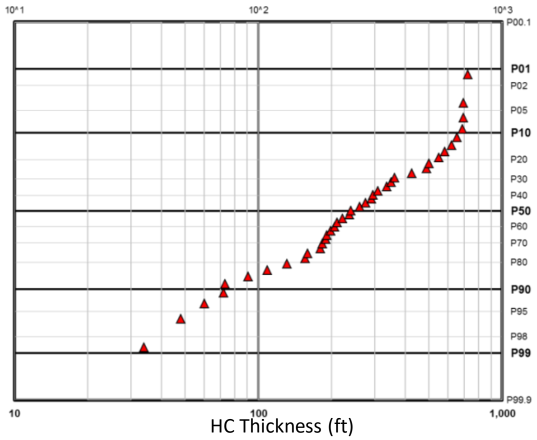


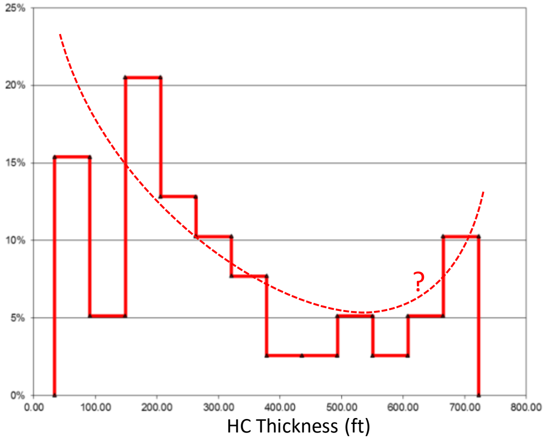




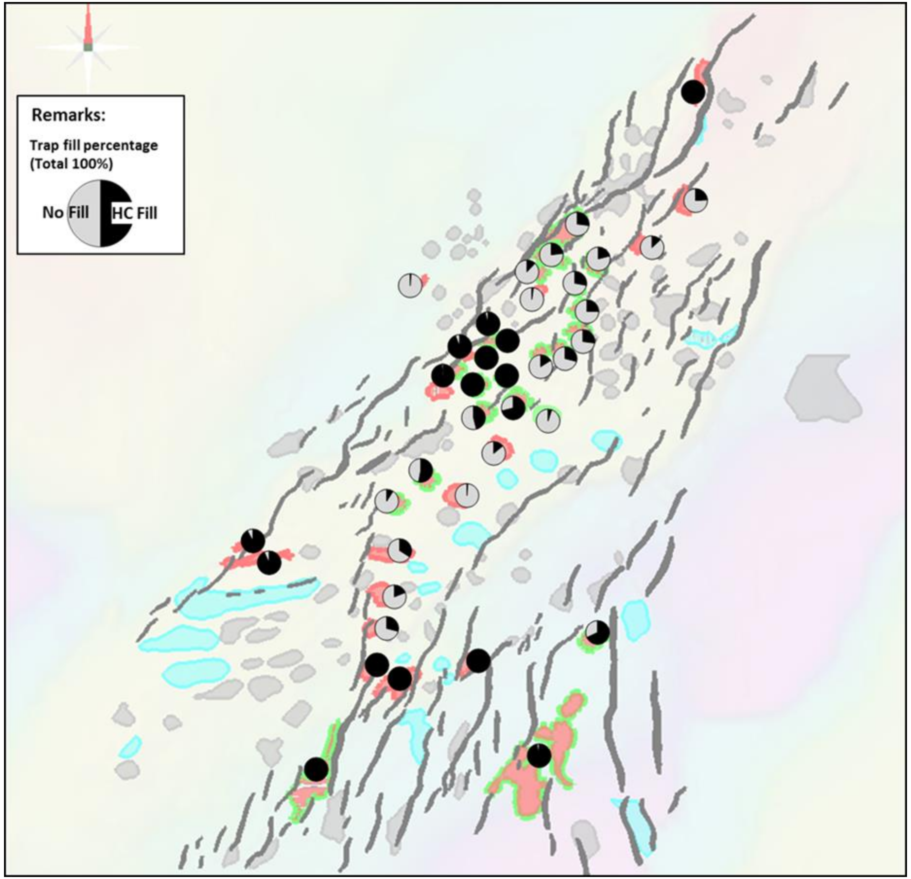
HYDROCARBON THICKNESS

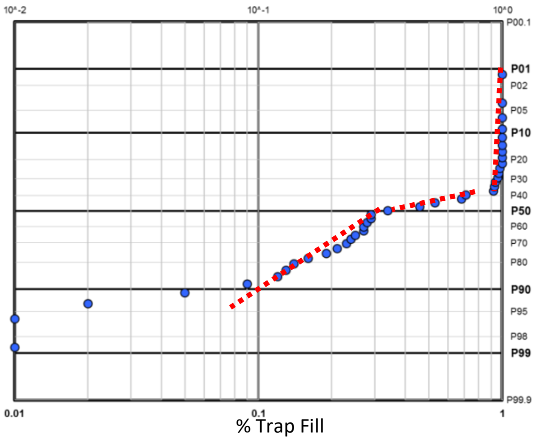


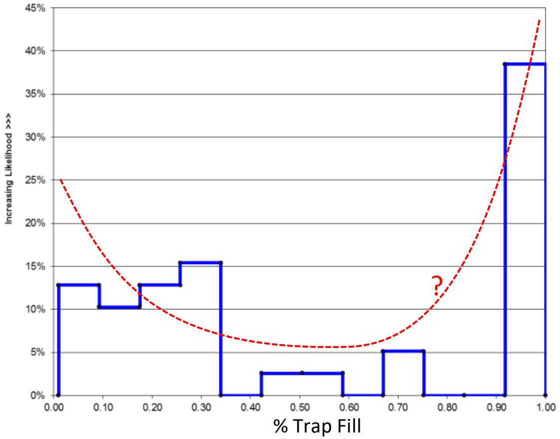




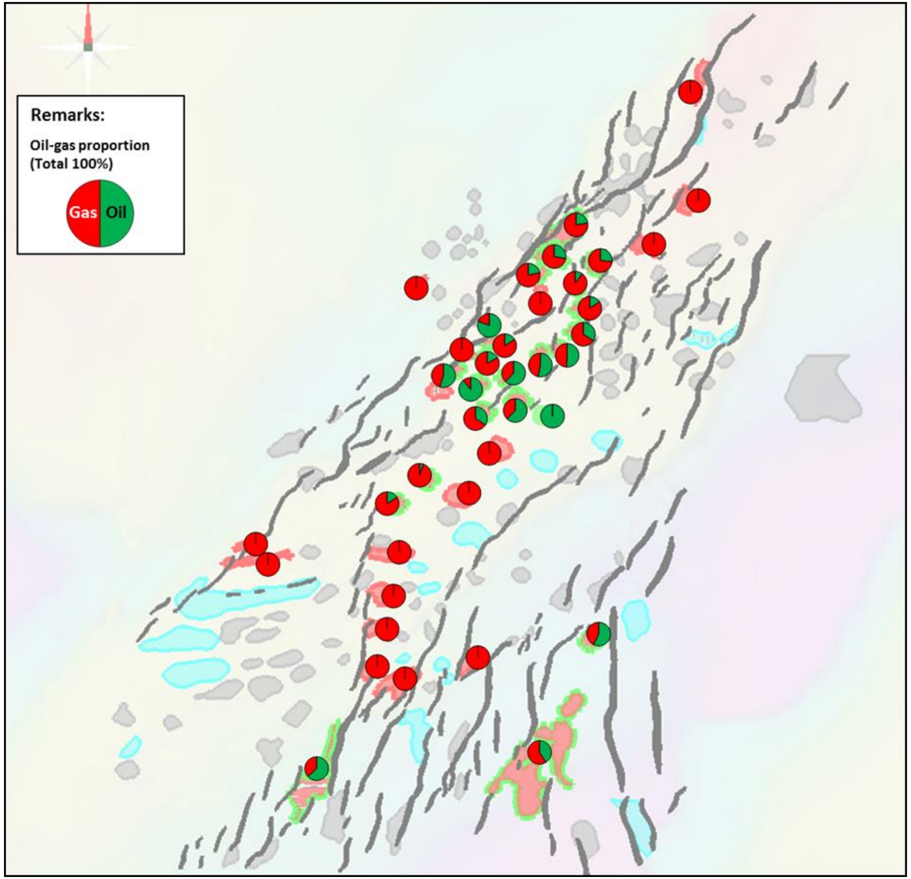
TRAP FILL PERCENTAGE

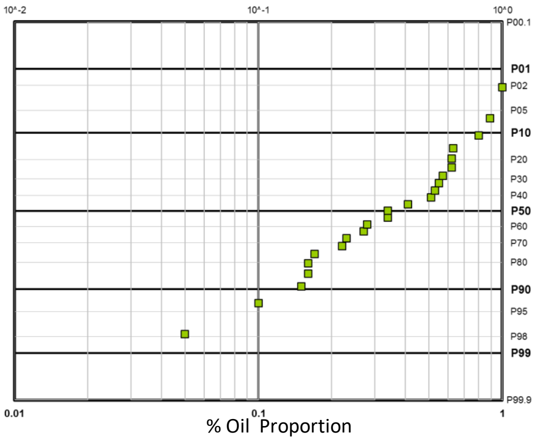


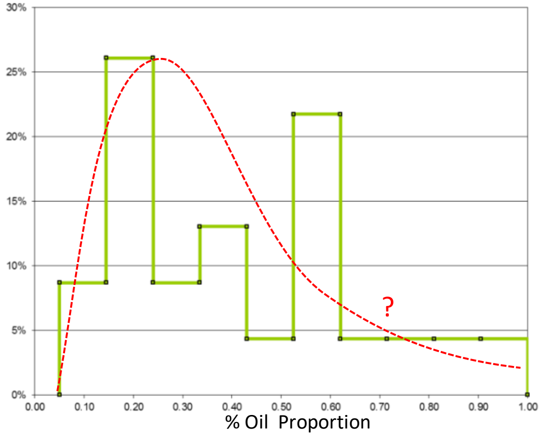




OIL-GAS PROPORTION

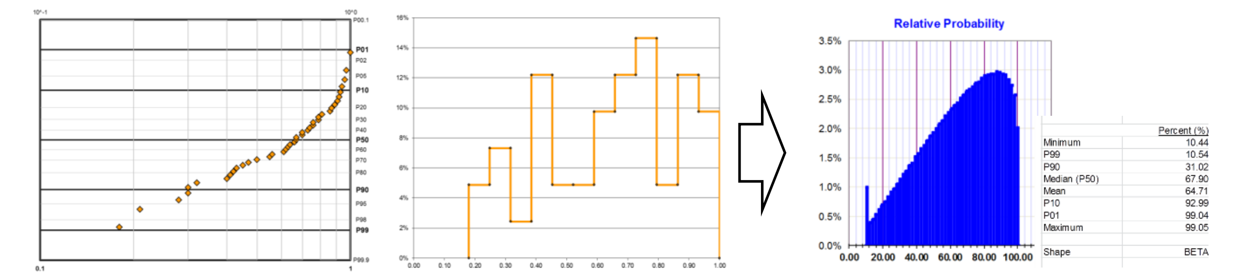




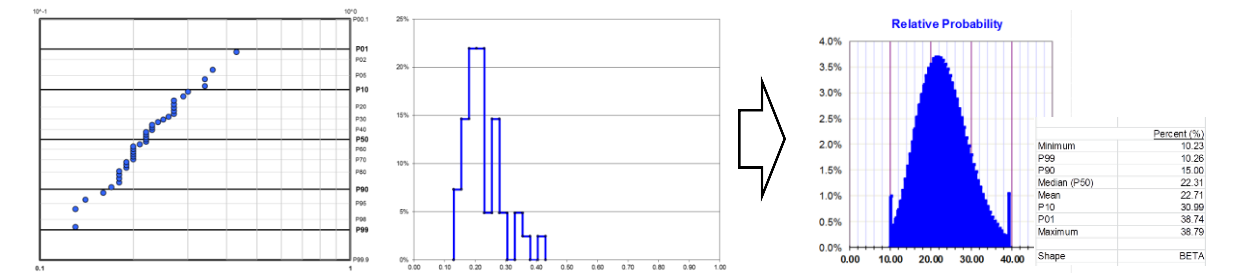


RESERVOIR PROPERTIES

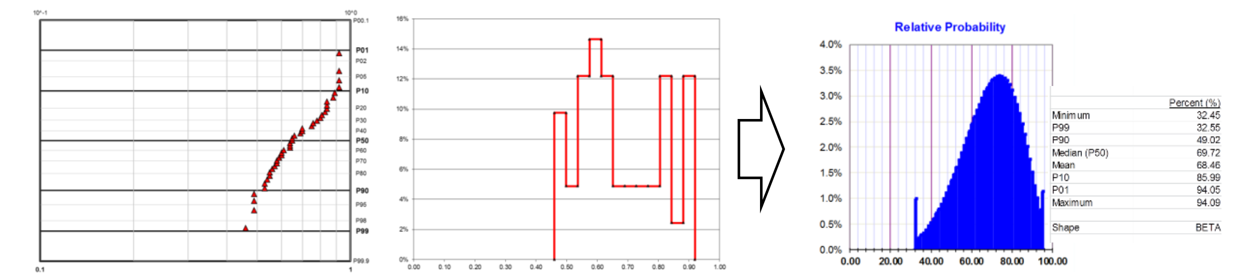
Avg. Net to Gross



Avg. Eff. Porosity



Avg. HC Saturation



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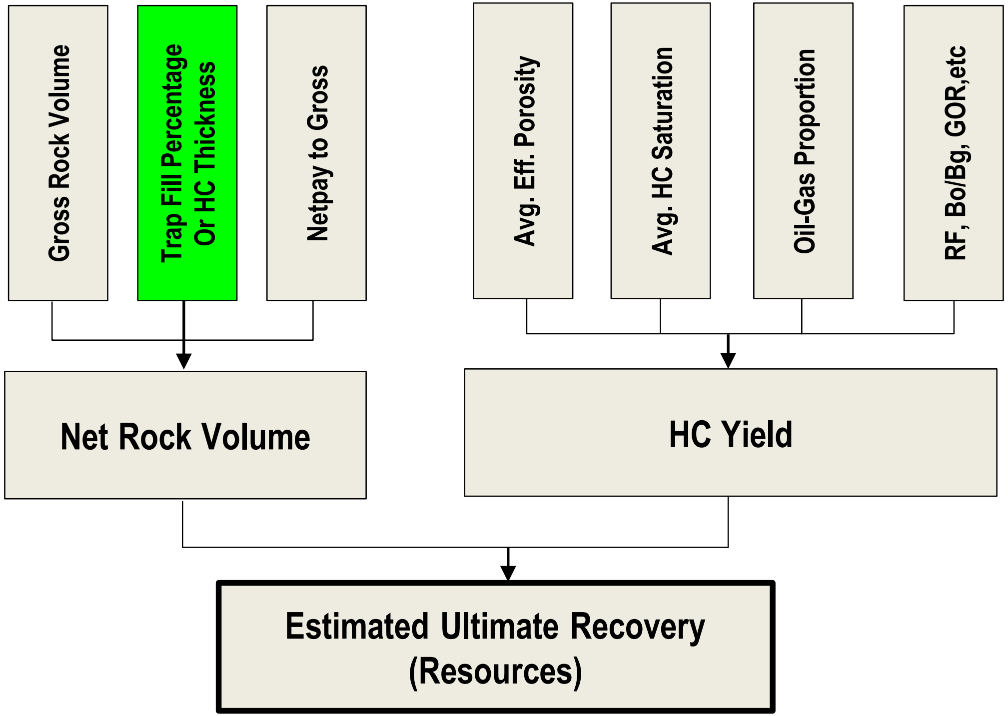
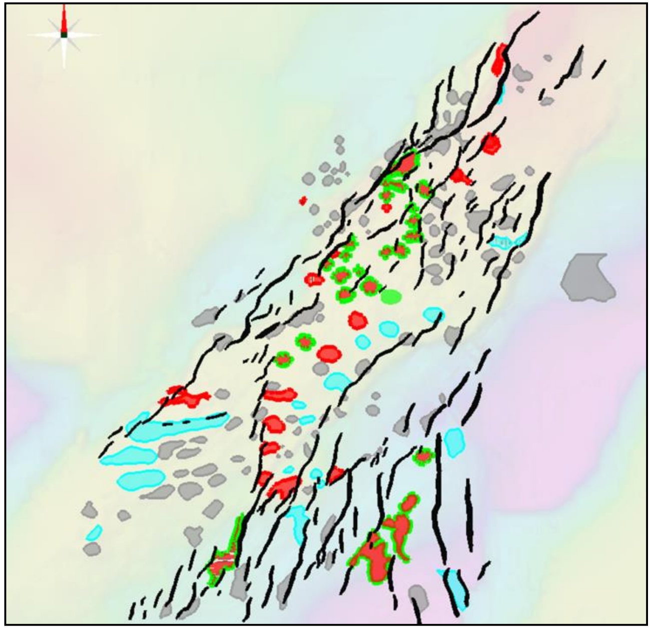
PROSPECTIVE RESOURCES ESTIMATION



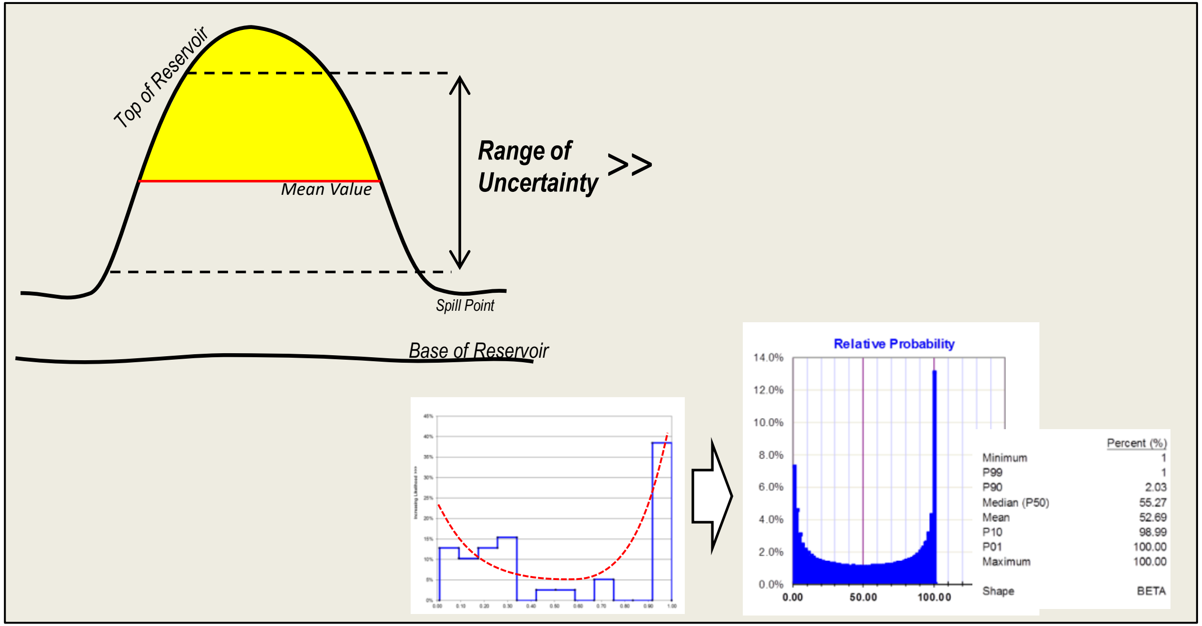
: Main parameter that most contribute to “Total Resources”

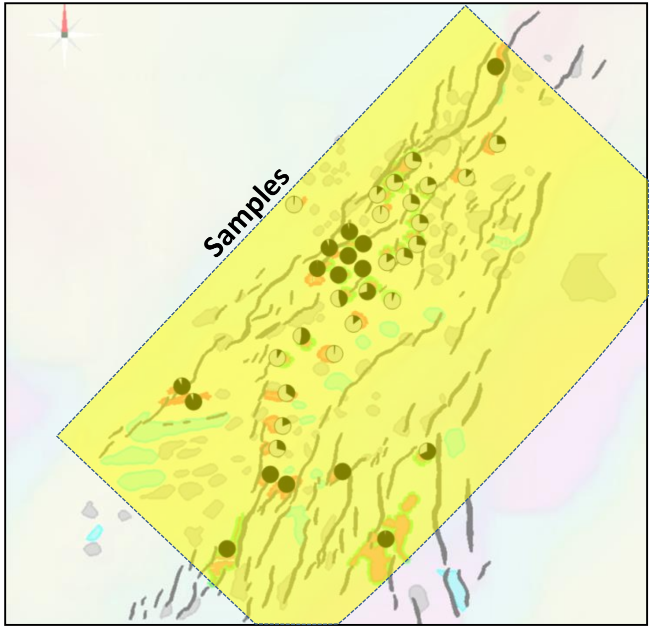
ESTIMATION METHOD

1. Deterministic (very not recommended)
2. Probabilistic – Distribution of Entire Area
3. Probabilistic – Distribution of Specific Trend
4. Probabilistic – Seismic HC Prediction



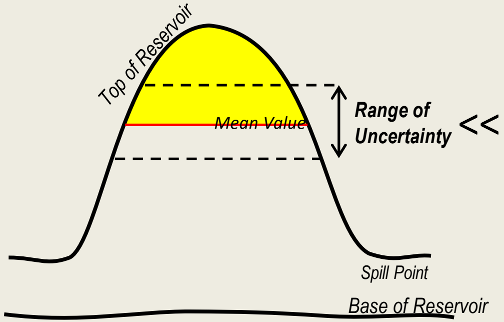
PROBABILISTIC – DISTRIBUTION OF ENTIRE AREA

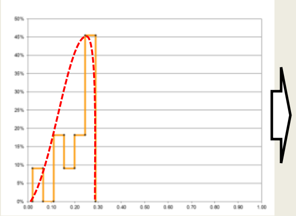


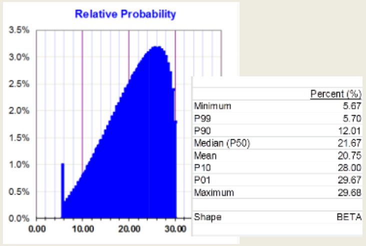


PROBABILISTIC – DISTRIBUTION OF SPECIFIC TREND

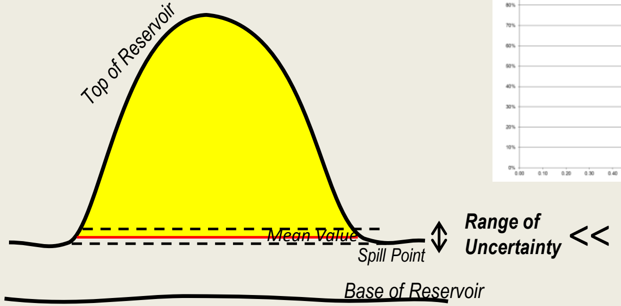
Samples-1

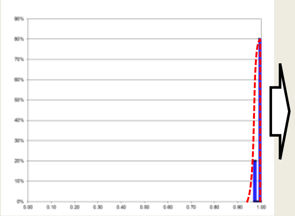


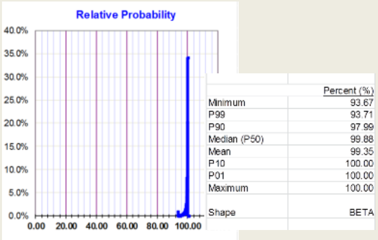


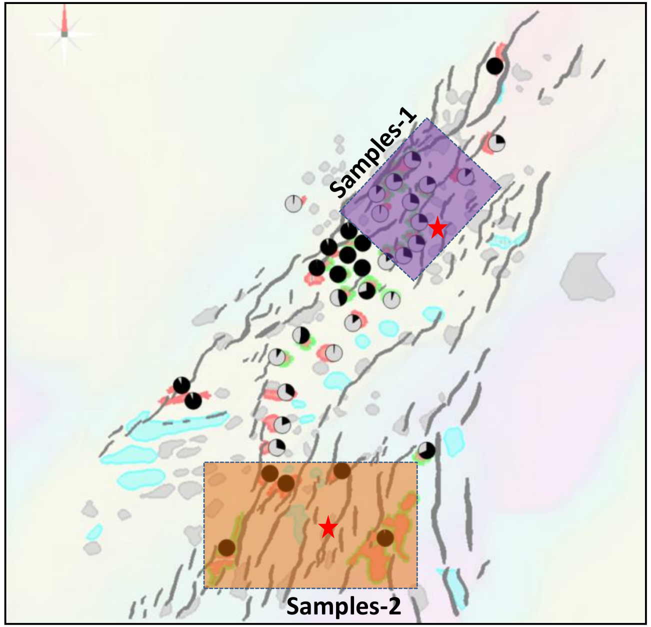


Samples-2

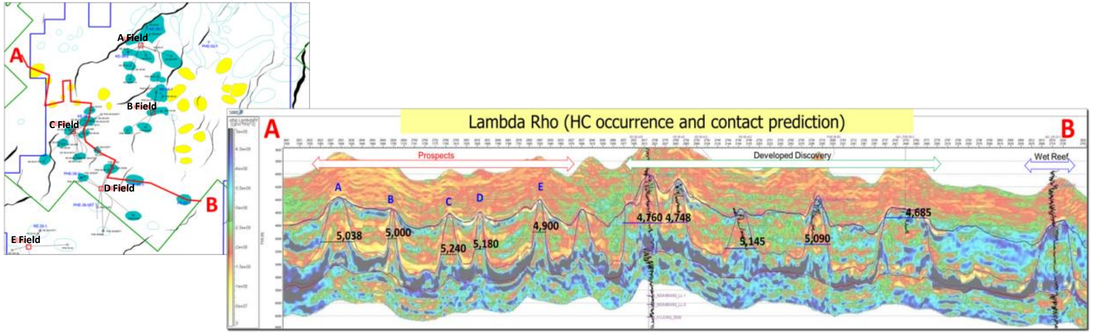


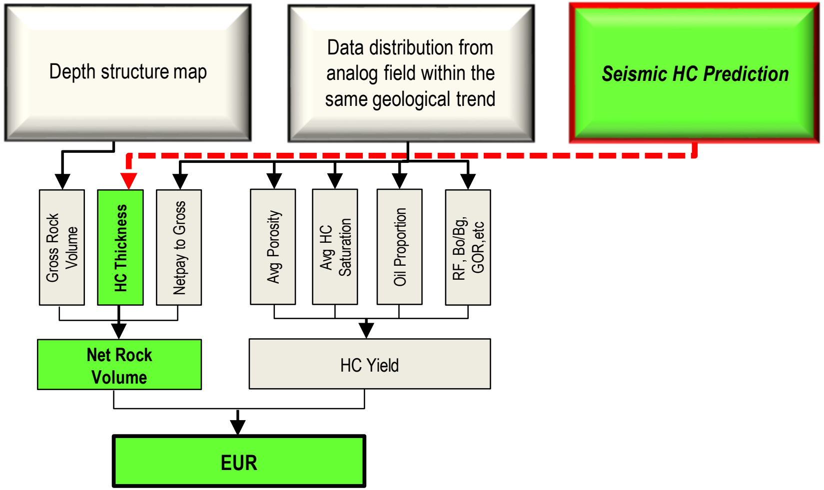






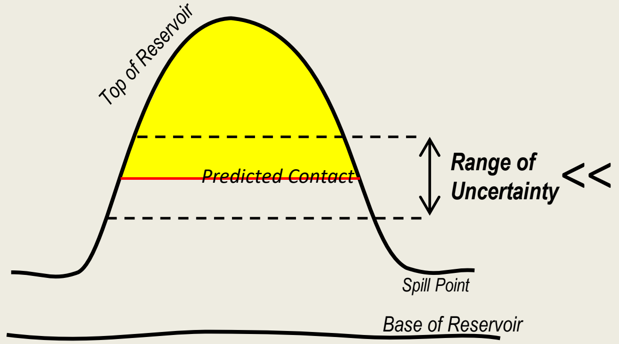
PROBABILISTIC – SEISMIC HC PREDICTION

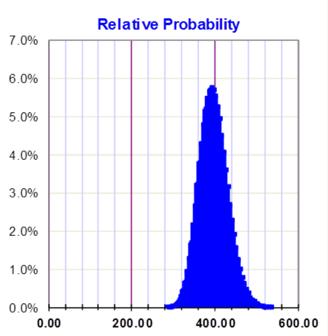




Example:

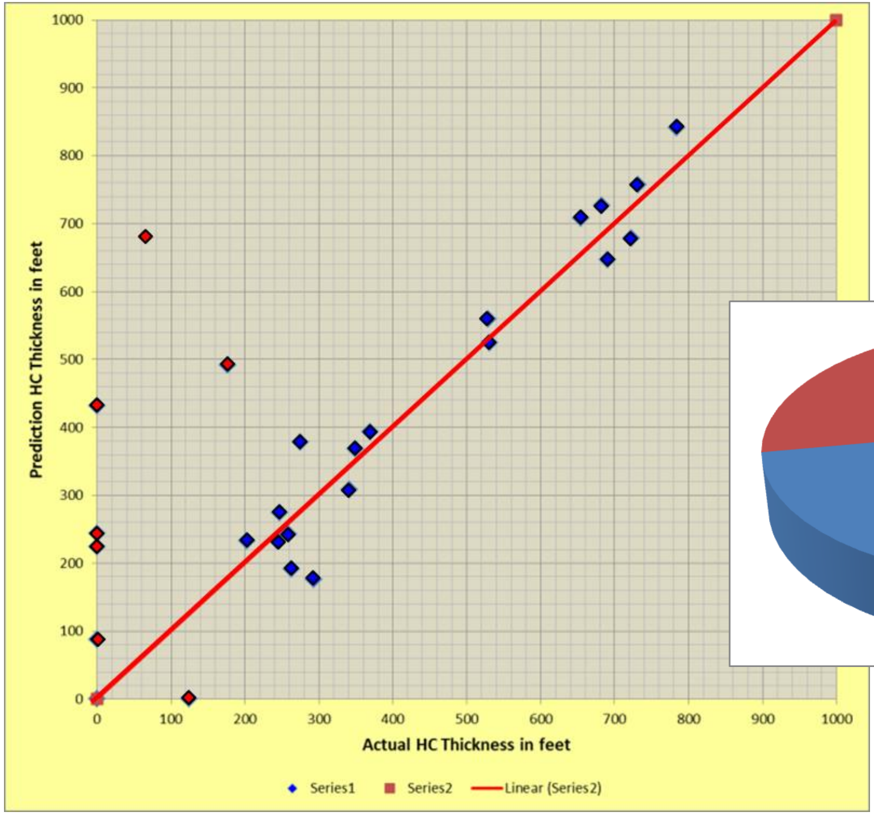
Predicted HC thickness 400ft. With max error ±80ft.

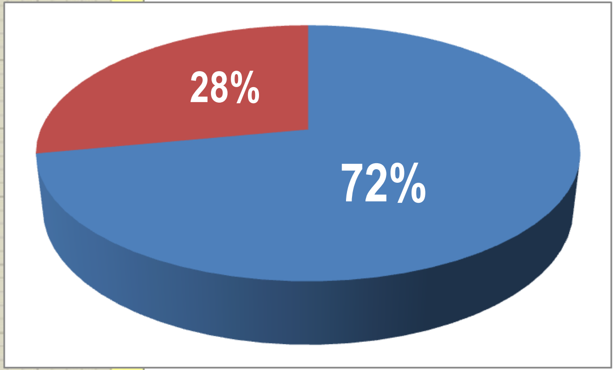




	Feet
Minimum	287.87
P99	320.2
P90	350.53
Median (P50)	391.92
Mean	393.4
P10	438.2
P01	479.70
Maximum	533.57
Shape	LOGNORMAL

PROBABILISTIC – SEISMIC HC PREDICTION





72% match between predictions and results

<u>**28% do not match**</u>

ESTIMATION METHOD SUMMARY

Deterministic

- Simplest method

- Single possible outcome
- Not intended to deal with uncertainties

Probabilistic – Entire Area

- Relatively safe if dealing with area with extreme differences

- High distribution variance
- Gives no specific direction/tendency

Probabilistic – Specific Trend

- Low distribution variance
- Gives specific direction/tendency

- Depends on samples definition
- May find pitfall in area with extreme differences

Probabilistic – Seismic HC Prediction

- Low distribution variance
- Gives specific direction/tendency

- Depends on reliability of prediction method accuracy
- May find pitfall for any prediction error

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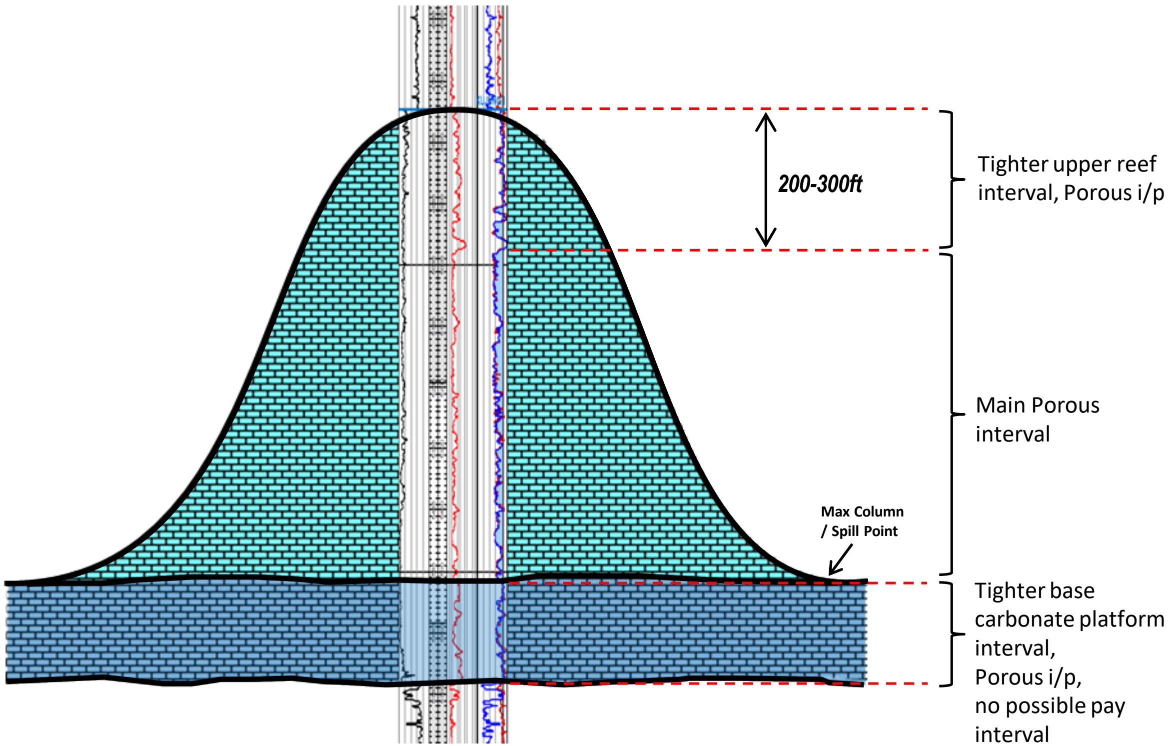
EFFORTS FOR UNCERTAINTIES

1. Define concepts and/or analog samples that are considered to be the most representative of the conditions that may occur from certain prospects.

2. Always do reality checks
   - ✓ Maps
   - ✓ Parameters
   - ✓ Highest/lowest possible outcome

3. Applying correlation between related parameters

HC GROSS THICKNESS – NTG CORRELATION

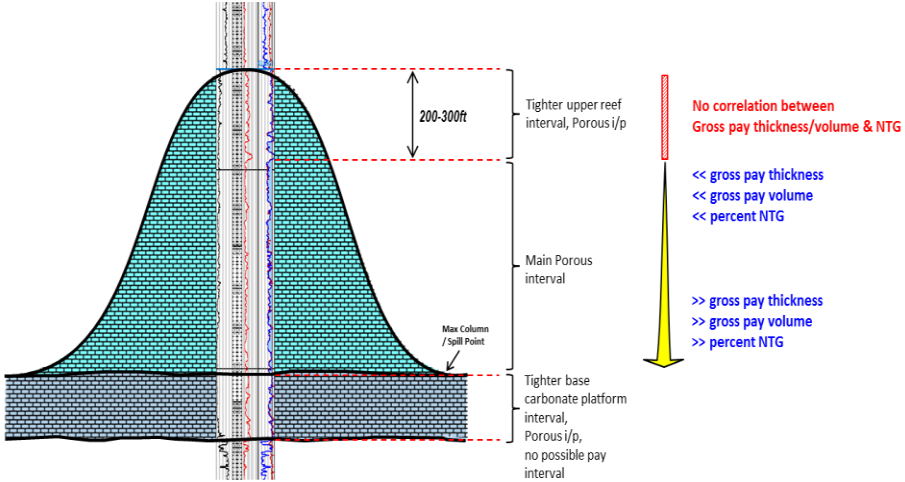


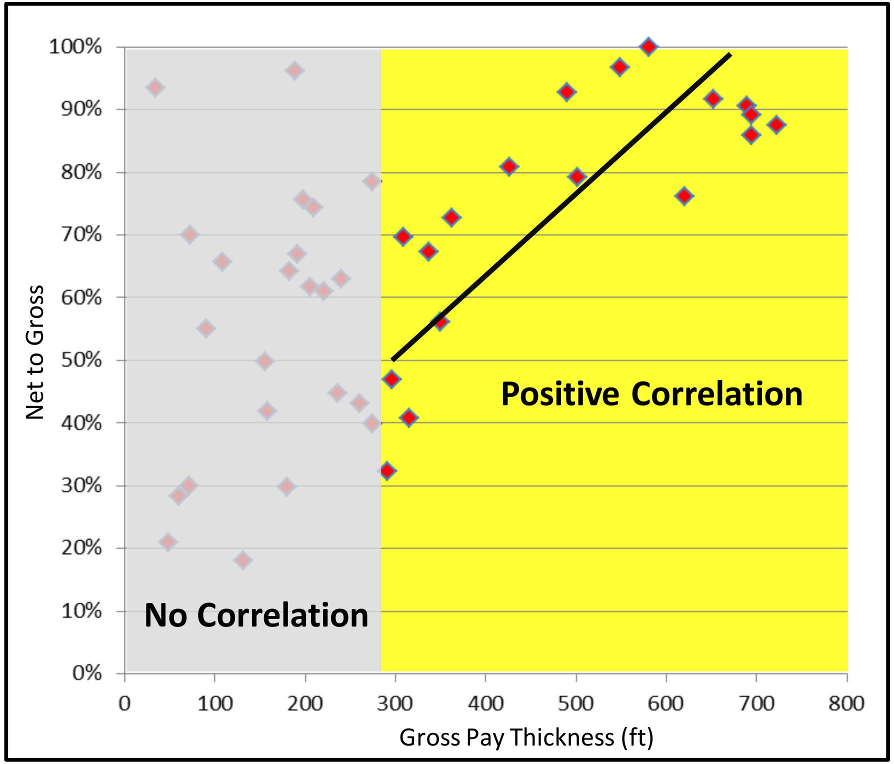
No correlation between
Gross pay thickness/volume & NTG

<< gross pay thickness
<< gross pay volume
<< percent NTG

>> gross pay thickness
>> gross pay volume
>> percent NTG

HC GROSS THICKNESS – NTG CORRELATION





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CONCLUSIONS

1. JS-1 Ridge Structure has encountered hydrocarbon accumulation variation among the build-up closures, with currently 65% discovery success percentage. For the group of HC-filled reefs, the statistic suggests very high variation with skewed-right shape distribution (log-normal).

2. At least there are four estimating method options: deterministic, probabilistic using distribution of entire area, probabilistic using distribution of specific trend and probabilistic using seismic HC prediction. Every option has different advantages and disadvantages, except for deterministic method which is very not recommended to be used.

3. The variance of the distribution should be defined carefully so it will not too high and results in an improper decision or too low so that ignores possible outcome that may occurs.

4. Input from advance geological and geophysical analysis is absolutely necessary to reduce variance of particular probability distribution and to improve resources estimation. The target is to reduce uncertainty as much as possible but still pay attention to highest/lowest possible outcome.

Thank You