P - 427

Drilling Decisions Using Probabilistic Risk Analysis

Badsha Basu Roy*, Debajyoti Guha, Rajatesh Ganguly, Kapil Agarwal
**Reliance Industries Limited, Petroleum Business (E&P), Mumbai-400001, India*
E-mail : badsha.basuroy@ril.com

Summary

Geological and economical risk assessment plays a critical role in decision making during the life cycle of any block. With this objective similar exercise were performed for one shallow water block. Prior to the study there were two existing wells and a third well was in planning stage for drilling. The study tried to integrate all available information for the proposed leads and promote them to economical prospects. This paper tries to present a framework to firm up drilling decisions considering the risk factors.

Introduction

Geological risks associated to a hydrocarbon accumulation are attributed to source, timing/migration, reservoir, closure and containment. Where each of the components plays their own share of role to give rise to different play types. At the same time the economic risks are governed by accumulation area, net pay thickness, effective reservoir porosity, hydrocarbon saturation, geometric factor, recovery efficiency and formation volume factor (FVF). So, with number of possible and favorable play types and accumulation scenarios, Risk Analysis becomes essential for identifying probable threats to success of any well and vulnerabilities arising from the well result for decision making during life term of the project. So with the help of Risk analysis and portfolio management the exploration risk can be considerably be reduced in portfolio scale (Rose, 1999).

The exploration block under study already had two drilled wells at 15 km apart. In both the wells investigation target was at Miocene level in similar depth. One of the well was a discovery well, whereas, the other one was a dry hole. Now another exploration well was to be drilled, which had multiple number of leads to choose from as possible drilling prospects.

Methodology

Probabilistic method of risk analysis was performed to bring out the Geological Chance Factors and Estimated Resources. Monte-Carlo Simulation which uses random numbers and probabilities to solve problem, were performed over the available information to quantify chance of occurrence of a particular event (Hoffman, 1998; Metropolis and Ulam, 1949). The sequence of work carried out was as follows:

1. Geological and economical risk analysis of the undrilled leads were carried out using chance factor of occurrence of source, reservoir, timing/migration, closure, containment, productive area, average net pay, porosity, hydrocarbon saturation, geometric factor, recovery efficiency and FVF as inputs.

2. Above inputs for the leads were quantified using the seismic and available well data of the shallow water block

3. Normal, Lognormal and Mixed distributions were used for individual analysis of subset data.

4. Probabilistic analysis was performed on the subset inputs based on their P90 and P10 values. In case of FVF only single value corresponding to each lead were chosen.

5. Composite geological chance factor and reserves of multi zone leads were used in Monte-Carlo simulation to bring out probability of success of the well. Dependency factor of zones w.r.t each other were also considered for assigning probability conditions.

Results

Assessment of Geological Chance Factor for individual leads and their respective zones were performed on a range of values for all the leads (Fig 1).

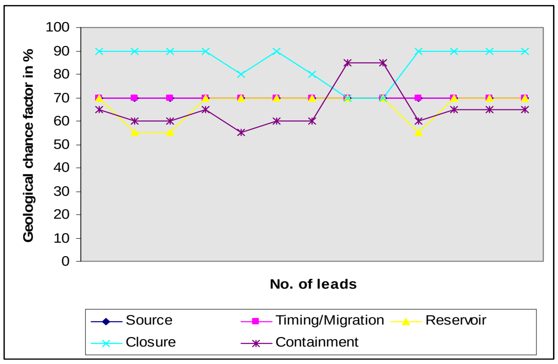

Fig 1: Potential chance of occurrence of components of Petroleum System in the block

Similarly, the calculation of resource and reserves were carried out using Monte-Carlo simulation for each of the individual leads on the basis of the available information (Fig 2.1 and 2.2)

The probability analysis of subset input data resulted P50, Mean (P99->P1), P1 and P99 values of each parameter.

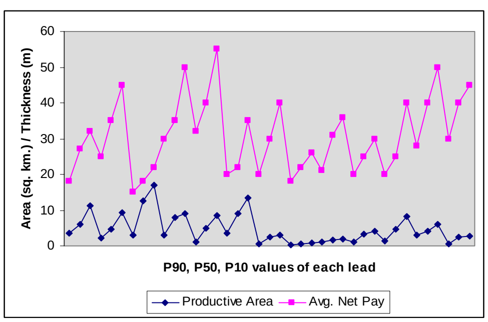

Fig 2.1: Variation of Area and Thickness for different leads

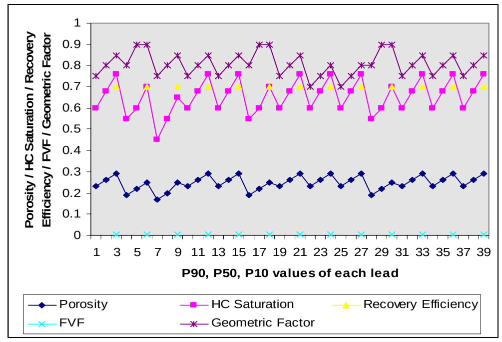

Fig 2.2: Variation of other essential factors for estimation of resource and reserves for different leads

These in turn were used in Monte-Carlo simulation to bring out the P1, P10, P50, Mean (P99->P1), P90 and P99 values of resource and reserves. The findings of P1 and P99 values helped in visualizing extreme case scenarios for a discovery well.

While running the simulation a threshold value for economic success was also assigned. So that, apart from Geological Chance of Success, the study can also yield Economic Chance of Success for benefiting the decision making. This was followed by the Reserve vs. Chance analysis (as shown in Fig 3) for all the leads individually to rate them accordingly.

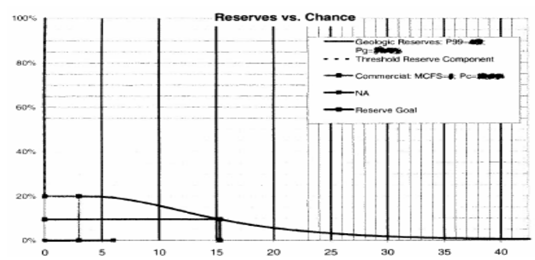

Fig 3: Reserve vs. Chance analysis of one of the zone of a lead

On the basis of the above analysis and integrated geological knowledge of the area two leads X and Y were promoted to probable economic drillable prospects. Chances of Success for both the leads, as derived from the exercise were tabulated in Table 1 and 2.

Table1: Multi zone parameters for Prospect X

Prospect X			
Zone Names	**Zone Age**	**Chance of Geological success (%)**	**Chance Factor Relationship**
A	Mid Miocene	20.1	Largely Independent
B	Late Eocene	14.6	Largely Independent
C	Paleocene	14.6	Largely Independent

Table 2: Multi zone parameters for Prospect Y

Prospect Y			
Zone Names	**Zone Age**	**Chance of Geological success (%)**	**Chance Factor Relationship**
A	Late Miocene	20.1	Largely Independent
B	Early Miocene	14.6	Largely Independent

As depicted in the Table 1 and 2 probability relations between the multiple zones were assigned based on the chance factor of their relationship and Monte-Carlo simulation was run with 10,000 iterations. This in turn helped to derive the expected successful zone combination for prospect X and Y (Fig 4 and Fig 5).

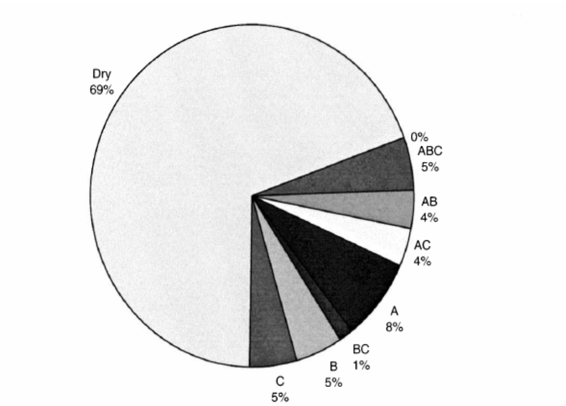

Fig 4: Chance of success for prospect X

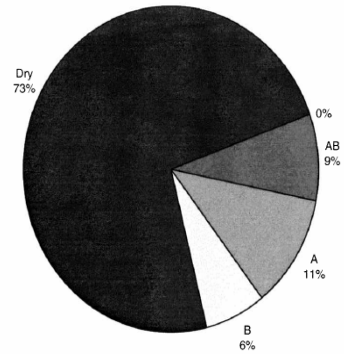

Fig 5: Chance of success for prospect X

The resulted output assigned a risk factor of 69% and 73% for prospect X and Y respectively.

Decision trees which are a graphic representation of options and its consequences were constructed for each prospect, taking into consideration the geological and economic risks associated. In this case the present study lead us to rank prospect X is better than prospect Y.

Conclusion

Considering all other geoscientific parameters and incorporating the above study results as a value addition tool, the prospect X which had shown a lower risk percentage of drilling a dry hole was finally drilled. The result was promising as it turned out to be a discovery.

Comparison of estimated pre-drill volumes and post-drill results will improve estimates for resource and reserve for future drilling programs. This will result into risk mitigation and selective investment of available funds in most efficient manner to maximize profitability.

References

Hoffman, P., 1998, “The Man Who Loved Only Numbers: The Story of Paul Erdos and the Search for Mathematical Truth”, New York: Hyperion, 238-239.

Metropolis, N. and Ulam, S., 1949, "The Monte Carlo Method", J. Amer. Stat. Assoc. 44, 335-341.

Rose, P. R., February 1999, “Taking the risk out of petroleum exploration; the adoption of systematic risk analysis by international corporations during the 1990s”, The Leading Edge, 192-199.

Acknowledgement

The authors are grateful to Reliance Industries Ltd. For encouragement and permission to publish this paper. In addition authors would like to thank Sh. Sankar Nayak, Sh. Pranaya Sangvai and Ms. Rajlaxmi Rout for their valuable suggestion, encouragement and contribution during the work and while writing this paper.

The authors would like to put their special thanks to M/S. Rose & Associates for the evaluation version software they provided upon which the study was carried out and technical explanations on the supporting study materials for software.