Oil and Gas Exploration Planning using VOI Technique

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Abstract. Paper deals with actual problem about making decisions during field development. The main aim was to apply method "Value of information" in order to estimate the necessity of field exploration works and show the effectiveness of this method. The object of analysis - field X, which is located in the Eastern Siberia. The reservoir is B13 formation of Vend age. The Field has complex structure, and divided into blocks by faults. During evaluation of the project, main uncertainties and oil in place were obtained for three blocks of the field. According to uncertainty analysis, it was suggested to drill a new exploration well, and value of information method was applied to estimate results from this exploration works. Economic evaluation of the value of information method was made by choosing optimal development strategy. According to the obtained results, drilling of the exploration wells for blocks 1 and 3 of the field X is a good decision, while drilling a well in the second block is risky and not recommended. Also using the value of information, optimal well locations were advised - well l_le for the first block, and well 3_3 for the third block.

1. Introduction

The paper deals with actual problem about making decisions during field development. Nowadays Gazpromneft spends a lot of money for exploration of the field while not all getting information is useful. So, the main idea was to show how method “Value of information” can be used for proving the necessity of exploration works and what potential economic benefits it can bring.

The object of analysis - field X, which is located in the Eastern Siberia. The reservoir is B13 formation of Vend age. According to seismic surveys, infill drilling data and results of well logging, the field is divided into several blocks, boundaries of which are zones of the deep faults. During interpretation of seismic data it was found and traced a lot of different faults. Reservoir properties are very heterogeneous. All calculations were done for 3 blocks of the field.

The value-of information analysis is principal estimation of expected monetary value (EMV) from obtained information. It obtains benefits that additional information can give in comparison if no information available:

VOI= [EMV with additional information] – [EMV without additional information].

If the difference in expected monetary values between scenario with and without data acquisition is not enough (or even negative) to cover the costs of exploration work, it can be a good reason not to acquire the data.

Method of estimation the value of information can help to obtain the potential value of additional information and can be used as powerful technique for making decisions in the oil and gas industry. In general, VOI analysis focused on the main uncertainties which can affect the amount of STOOIP and NPV value, and how additional information can change the decisions about development of the field and further investment decisions. This method leads to effective usage of data. As a result, the main idea of VOI analysis is to estimate how much information obtained during exploration work is worth, which, in its turn, enables better evaluation of profitability of the project as a whole [1, 2, 3, 4, 5, 6].

2. Method

The first step of the analysis was to estimate STOOIP and associated uncertainties. For doing this, geological model for the field X was created based on seismic surveys, interpreted well logs and variograms. Distribution of STOOIP was obtained using Monte Carlo method (figure 1). And the analysis of influenced factors was done.

First of all, structural uncertainties are related to seismic survey and horizon modeling process. Depending on seismic surveys resolution, the standard deviations were obtained (for 3D seismic – 8m, 2D seismic – 28m).

The second uncertainty type is size and distribution of sandbodies in 3D space. Dimension of reservoir bodies depends on the variogram ranges. Because the field is only on exploration stage and there is a large distance between wells, statistical analysis using well data is not quite accurate. That is why ranges of variogram were taken as triangular distribution. Changes in ranges were estimated through statistical analysis and literature information [7, 8, 9, 10] according to the depositional environment. Uncertainty in distribution of the reservoir was taken into account by stochastic element of the model.

Thirdly, there is uncertainty connected with OWC level. Its estimation was made on the base of having well data and structural map. As a result, the interval of OWC level change was estimated for each block (lower OWC level – the bottom of sandbodies for each block, the upper OWC – lower interval of perforation) and triangular distributions of OWC were used during STOOIP estimation.

Porosity and oil saturation were defined as normal distribution with associated mean value and standard deviation (for porosity: mean – 0.11, standard deviation – 0.01; for oil saturation: mean – 0.66, standard deviation – 0.036).

As a result, P50, P10 and P90 probabilities of STOOIP and associated with them uncertainties were obtained (figures 1). Sensitivity analysis is the first step in VOI analysis. It shows key uncertainties, which are affected on STOOIP, and expected exploration works according to them.

As it can be seen from figure 1, level of OWC is one of the most important factors, so it was planned to drill exploration wells for clarifying these values.

The next step of the VOI analysis is estimation of the probable results, which can be obtained after drilling of the exploration wells. For each block the possible positions of wells were suggested (Figure 2), for example, for the first block – 1_1e, 1_2e, 1_3e and 1_4e wells.

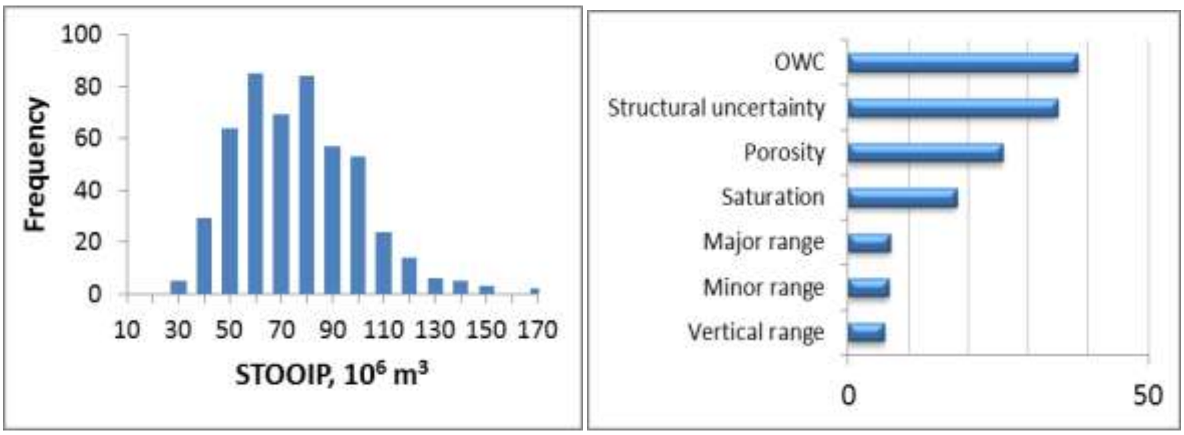

Figure 1. STOOIP distribution and sensitivity analysis.

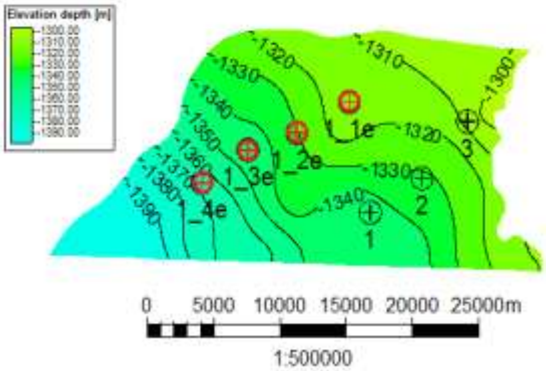

Figure 2. Structural map of block (red – modelled wells, black – real wells).

New exploration well can perforate three zones – oil zone, water zone or oil water zone. Because of structural uncertainty and uncertainty in OWC level, opened-up zone is different. In order to determine the probability of each zone occurrence, workflow was created for 500 realizations for the definite version of well location. The algorithm of identification of a zone is the following:

In the modelled well, property "above contact" is estimated for the reservoir facies. It is equal to 0 if sandbodies are located below oil water contact, and more then 0, if they are situated above OWC.

According to the value of "above contact", it is possible to estimate in which zone this well broachs: above contact>0 – oil zone, above contact=0 – water zone, above contact≥0 – oil water zone.

As a result, modelled STOOIP is assigned to the zone which was obtained.

Based on the described algorithm, workflow program was created. After modelling of 500 different realization of STOOIP, which depend on distributions of analyzed uncertainties, the probability of occurrence of each zone was estimated. This method allows not only estimating the result, which can give exploration well, but also estimating STOOIP for the each option. Distribution of STOOIP in each zone for different well is shown in Figures 3, 4.

The information that minimizes the existing uncertainties has the highest value. Uncertainties in OWC level can be decreased or delayed if well opens-up oil water zone. From this point of view, the well which has more probability is the best option.

The important step of VOI analysis is economic evaluation. Decrease in the uncertainties leads to more accurate STOOIP estimation and also allows taking optimal decision on further development of the field.

Decision on optimal development strategy was chosen according to the net pay value, which was calculated for given distribution of STOOIP. The development scenarios were altered by changing such parameters as number of wells and pipeline capacity. As a result, the option with the maximum mean NPV for a definite STOOIP distribution was taken as optimal.

Because the distribution of STOOIP for each case differs from each other, development strategy and, as a consequence, NPV value will change. Therefore, NPV with and without information will be different.

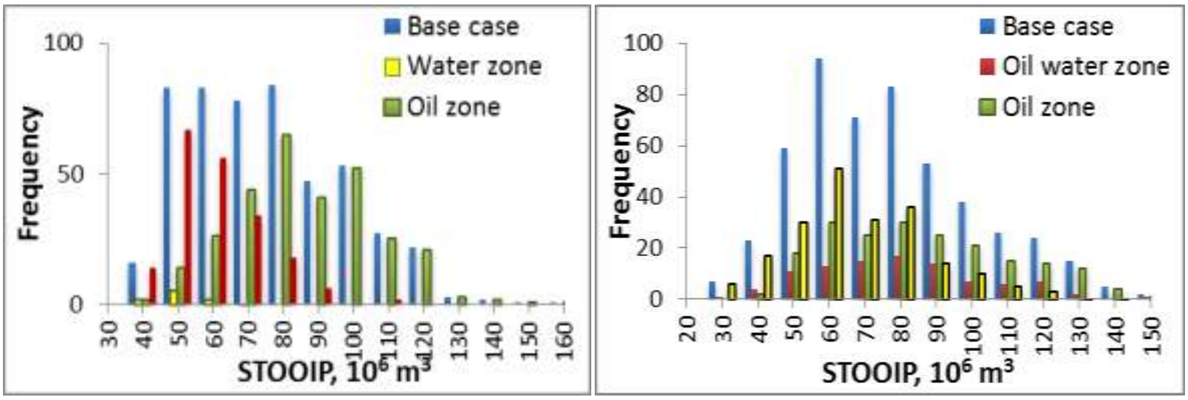

Figure 3. Distribution of STOOIP for different zones for wells 1_1e (left) and 1_2e (right).

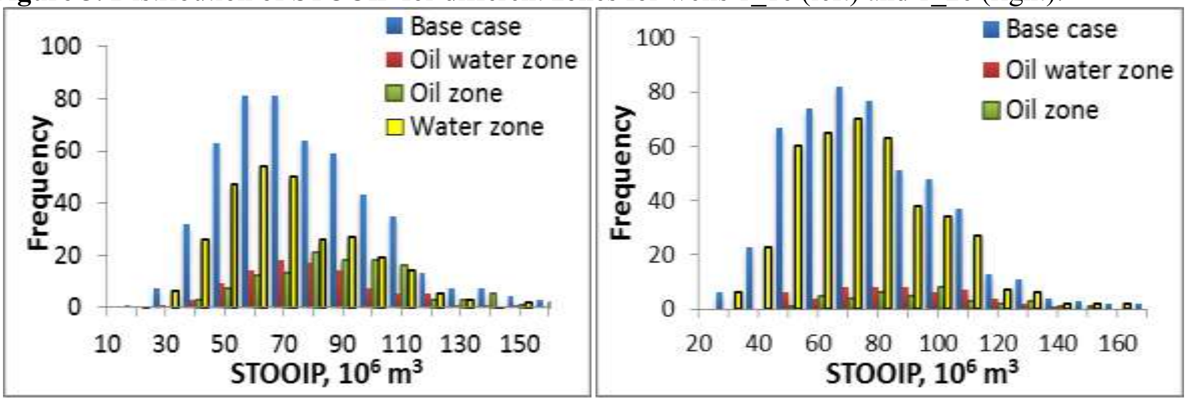

Figure 4. Distribution of STOOIP for different zones for wells 1_3e (left) and 1_4e (right).

Taking into account the probability of occurrence of each case, and calculated NPV, the value of information can be estimated as difference between the net pay value, estimated according to the modelled variants, NPV for the base strategy of development without information and the costs, which are spent on drilling of exploration well:

According to the results, drilling of the exploration wells for blocks 1 and 3 of the field X is a good decision (VOI for first block – 1.5 billion rub, for third block – 3 billion rub), while drilling of a well in the second block is risky (VOI=-170 mln.rub) and not recommended, which can lead to the decrease in profits from this block. Optimal well location according to the value of information – well 1_1e for the first block, and well 3_3 for the third block.

In order to estimate the accuracy of the method, real and modelled data must be compared. During 2014 and 2015 years, there were drilled exploration wells for the field X, corresponding to model wells. After it, STOOIP was estimated more correctly, and associated with them uncertainties change their intervals. Change in STOOIP value is affected on development decision as it was described above. To obtain the real value of information, possible profit was calculated if no exploration work was done, and the development strategy was not changed. STOOIP values were assigned from analysis after drilling exploration work that allows not overestimating the value of information.

The value of information is estimated as difference between NPV with and without information, taking into account the cost of drilling the exploration well (170 mln.rub). The final results of VOI values: for first block: 4.9 billion rub, second block - -170 mln.rub, third block – 10.7 billion rub.

Comparing modelled and real values of the information (VOI), it can be concluded that this method shows good result during making decisions on drilling of the exploration wells. For the first block, as it can be seen from Figure 5, modelling of exploration well was recognized because the change in STOOIP distribution may change the decision on the development of the field. In fact we can see, the

STOOIP was increased and development strategy was changed leading to big profits due to new information. Block 2 was not recognized for drilling of exploration well, so in reality the well brings profit losses. In the third block VOI analysis shows the justifiability of the exploration work. Despite the fact that STOOIP was decreased, the value of information is positive, because information about more accurate STOOIP distribution allowed us to revise the development strategy, which, in turn, brings profits in comparison with the previous strategy.

Block	VOI, mln.r
1	4 892.93
2	-170
3	10 687

Figure 5. VOI results.

3. Conclusion

During analysis, it was obtained that this method shows good result during making decisions on the drilling of the exploration wells. Economic effectiveness of applied method was proved by real data from the field X.

Also, it can be added that VOI analysis can be used as the most powerful tool for making decisions not only about the necessity of the exploration work, but it can be used for selecting different works and ranking the exploration work inside the field.

Taking into account exploration and prospect well data, the resulting map shows considerable detalization improvement for HC generation potential density of Bazhen suite in Tomsk region, and allows zoning the area according to the volumes of raw HC in bituminous formation. The comparative data analysis against specific geochemical core analysis results in previously and newly drilled wells showed good correlation, so it is possible to consider the presented map as a basis for commercial development of Bazhen suite reserves.

In order to differentiate the loss of bituminous formation generation potential resulting from hydrocarbon migration to underlying deposits, three types of deposit zones were distinguished: 1 - sandstones, 2 – alternating mudstones, sandstones and siltstones, 3 - shales. These types of lithological heterogeneity of deposits underlying the Bazhen suite allow estimating its residual generation potential at both qualitative (type 2) and quantitative (types 1, 3) levels. Taking into account the specific character of shale oil development, each type requires its own set of operating conditions.

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