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# ON DECISION IN GAMES OF STRATEGY MADE FOR AN EFFICIENT ARRANGEMENT OF WELL-BORING LOCATIONS FOR OIL AND GAS

**Abstract**

*The technology consumption on seismic operations and boring depends on their rational combination, in the given paper the method of modeling of rational combinations of boring and seismic operations, which are necessary for studying of efficiency of the existent territories and their resources was suggested.*

In recent years oil and gas production, its planning for the future represents a great urgency for the national economy in whole.

Decisions making in this activity and their efficiency are defined also by the natural conditions. The uncertainty of the nature and correspondingly accepted strategy by their own character are indistinct and ambiguous. Actually, human activity on nature is a conflict situation. Human tends to plan own actions to possess the natural resources with minimal costs. The nature, resisting human activity, keeping own resources compel him to spend energy and finds. Consequently, every strategy of the nature $Y$, corresponds to every human strategy $X$. Corresponding , payoff of the nature is $M(X,Y)$. Diagnosing of result and made decisions of such a process is complicated because of lack of their mathematical description. Moreover, it is very difficult to obtain this description. Game control system is intended for processes control, namely for the case of fame of their mathematical description. Each strategy of conflicting parties (nature and human) is considered as a random variable and their distribution laws are denoted $F(X)$ and $G(Y)$ respectively. At that

$$\int_0^x dF(x) = \int_0^y dG(y) = 1$$

Here $X$ and $Y$ are maximal values. Corresponding payoff value of the nature to prospector

$$M[F\,G] = \int_0^x \int_0^y M(x,y)\,dF(x)\,dG(y).$$

So, the problem is in providing such a strategy program $F(x)$ at which payoff of the nature to human is maximal one. At that hydrocarbons productions becomes maximal.

One of the corresponding ways for studying availability of the territory hydrocarbons are seismic. Geophysical and boring operations. Annually on Azerbaijan deposit occurrences several millions meters of prospecting boring are carried out, whose price reaches tremendous costs (in manats). Along with this extent of seismic operations is also concerned with tremendous costs. All these funds are used for studying the availability of the territory and extraction of hydrocarbons reserves.

Note, that the accuracy of orientation of borings on a concrete area depends on the prior information of seismic operations. In spite of the fact, that in comparison with boring they are cheaper but not in all geological conditions seismic method is effective. Consequently, the best combination of seismic prospecting and boring depends on costs of boring and seismic prospecting. Realization of one or another work requires attraction of great technologies which are necessary for studying availability the territory and hydrocarbons reserves production. Technology conceptions depend on the rational combination of executed seismic prospecting and boring. Modeling of the rational combination of seismic prospecting and boring, which are necessary for studying the effectiveness of existing territories and their resources (gas and oil resources) is carried out by the following way. We accept the following denotations:

$B$ is the volume of hydrocarbon recovered from one of deep wells;

$S$ is volume of Technology expended for realization of one seismic profile shooting;

$q$ is hydrocarbon volume;

$G(q)$ is the probability of that the volume of hydrocarbon in the existing territory doesn't exceed the value $q$;

$b$ is the number of deep wells;

$s$ is the number of seismic profile shootings;

$P_1$ is the probability of that boring is carried out after the realization of seismic operations;

$P_{1s}$ is the probability of the fact that boring is carried out after the realization of seismic operations;

$P_2$ is the probability of the fact that seismic profile shooting data are useful for the next well boring.

The volume of hydrocarbon extracted on existing territories rapidly tends to the true value as the number of wells increases, and it can be approximated by the functions:

$$q\left(1-\frac{1}{b+1}\right).$$

Later on we'll take into account that $P_{1s} : P_1$ will define the significance of seismic operations information for the next well location. Uncertainty of incoming information prevent prospector to make a decision on location of $b$ deep wells on the carried out $s_0$ number of seismic operations. I.e. on the information data of $s_0$-number of seismic operations to make decision if the prospector will realize the well boring or reject it in order to study availability and resources of new studied territory. So, uncertainty compels the prospector to make the best decision in two opposite situations; to realize deep wells location without using the obtained information on seismic prospecting or to use these data of the next well location. In the first case

$$M[XY]=q\left(1-\frac{1}{P_{1s}b+1}\right)-Bb-Ss_0. \tag{1}$$

The quantity (1) characterizes the game payment of the nature to human with orientation of seismic prospecting at deep wells location. The function includes expenditures on boring and seismic prospecting. The corresponding payment of the nature to human at deep wells location when data on seismic prospecting are ignored will be

$$M[XY]=\int_0^Q\left\{q\left(1-\frac{1}{P_1 b+1}\right)-Bb-Ss_0\right\}dG(q). \tag{2}$$

Here $Q$ is the maximal volume of hydrocarbon in the investigated territory. According to $P_2$, $(1-P_2)^{s_0}$ will be the probability of the fact, that realization of all shootings and obtained on basis of information will not be useful for deep wells location.

Consequently, $1-(1-P_2)s_0$ will be the probability of the fact that the results of seismic prospecting information will be qualitative and on this base deep wells location will be successful

$$M(b,s_0,q)=\int_0^Q\left\{(1-P_2)^{s_0}\left[q\left(1-\frac{1}{P_1b+1}\right)-Bb-Ss_0\right]dG(q)+\right.$$

$$\left.+\left[1-(1-P_2)^{s_0}\right]\left[q-\frac{q}{P_{1s}+1}-Bb-Ss_0\right]\right\}dG(q), \tag{3}$$

at that $\left[(1-P_2)^{s_0}-1-(1-P_2)^{s_0}\right]Ss_0=Ss_0$.

Payoff function (3) is constructed on the basis of logical reasoning, considering all the possible variants of uncertainties at decision making process. However, the function has such a structure, that in all variants of made decisions of the prospector it wins. The gain will be maximal, in the case, if he will determine an optimal amount of deep wells and corresponding number of seismic operations and, moreover, technologies for the refinement of hydrocarbon and their characteristics in the investigated areas. After the simple transformations from (3) we have

$$M=(1-P_2)^{s_0}\left[\left(1-\frac{1}{P_1b+1}\right)\hat{q}-Bb\right]+\left[1-(1-P_2)^{s_0}\right]\left[\left(1-\frac{1}{P_{1s}b+1}\right)\hat{q}-Bb\right]-Ss_0. \tag{4}$$

We maximize an expected payment of the nature by the number of wells $b$ and the number of seismic operations $s_0$. Then we obtain

$$(1-P_2)^{s_0}\left[\frac{P_1}{(P_1b+1)^2}-\frac{P_{1s}}{(P_{1s}b+1)^2}\right]\hat{q}+\frac{P_{is}\hat{q}}{(P_{1s}b+1)^2}=B,$$

$$(1-P_2)^{s_0}=\frac{S}{\Delta A\ln(1-P_2)}. \tag{5}$$

Here

$$\Delta A=\frac{\left(1-{P_{1s}}/{P_1}\right)b}{\left(b\,{P_{1s}}/{P_1}+{1}/{P}\right)(P_1b+1)}.$$

System (5)in the case of disuse of the seismic data gives the following solutions for the defining the necessary number of deep wells, hydrocarbon production and studying of availability of the given territory. Consequently, we have

$$b_{P_{20}}=\frac{1}{P_1}\left(\sqrt{\frac{P_1\hat{q}}{B}}-1\right). \tag{6}$$

At that $P_1\hat{q}>B$. The wells located subject to the data of seismic prospecting will be defined from the following formulas

$$b_{P_{21}}=\frac{1}{P_{1s}}\left[\sqrt{\frac{P_{1s}\hat{q}}{B}}-1\right]. \tag{7}$$

Here $P_{1s}\hat{q}>B$.

In accordance with (7) the necessary amount of seismic operations will be

$$s_0=-\frac{1}{\ln(1-P_2)}\ln\frac{\Delta A\ln(1-P_2)}{S}. \tag{8}$$

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Here $\Delta A \ln(1-P_2) > S$

$$\Delta A = \frac{\left(1 - {P_{1s}}/{P_1}\right) b}{\left(b\, {P_{1s}}/{P_1} + {1}/{P}\right)(P_1 b + 1)}. \qquad (9)$$

Substituting the value of $b$ from (7) into (9), we obtain

$$\Delta A = \frac{\dfrac{1}{P_{1s}}\left(1 - \dfrac{P_{1s}}{P_1}\right)\left(\sqrt{\dfrac{P_{1s}\hat{q}}{B}} - 1\right)}{\dfrac{1}{P_1}\sqrt{\dfrac{P_{1s}\hat{q}}{B}}\left[\dfrac{P_1}{P_{1s}}\left(\sqrt{\dfrac{P_{1s}\hat{q}}{B}} - 1\right) + 1\right]}. \qquad (10)$$

Here $P_{1s} : P_1$ defines the significance of the seismic prospecting for the next boring. The value of the given ration is defined by the geological conditions and also can serve as the value for estimating the arrangement of the well-boring locations on the given deposit. The loading diagram for the concrete deposit. The loading diagram for the concrete deposit is constructed by the two variants: 1) subject to the data of the seismic operations; 2) ignoring data of the seismic operations for the deep wells location. By the both variants statistical tables must be constructed by the value of hydrocarbon volume $\Re$ on the given territory based on which the distribution law is constructed, the value of $\Re$ hydrocarbon for the both variants in the territory. This table is in the following form:

**Table**

| № of investigation | The value of hydrocarbon volume subject to usage of the seismic prospecting data $q_1$ | The value of hydrocarbon volume ignoring seismic prospecting data $q_0$ |
|---|---|---|
| 1 | $q_{11}$ | $q_{01}$ |
| 2 | $q_{12}$ | $q_{02}$ |
| 3 | $q_{13}$ | $q_{03}$ |
| . | . | . |
| . | . | . |
| . | . | . |

By this table the distribution laws $G(q_1)$ and $G(q_0)$ can be established. Knowing $G(q_1)$ and $G(q_0)$ defines the uncertainty of the studied territory by availability of hydrocarbon by the both variants. This realizes by the following formulas

$$H_1 = \int_0^Q G(q_1) \log G(q_1)\, dq_1,$$

$$H_2 = \int_0^Q G(q_0) \log G(q_0)\, dq_0.$$

The mean value of the studied territory perceptivity hydrocarbon is defined in the following way

$$\hat{q}_1 = \int_0^Q q_1 \, dG(q_1),$$

$$\hat{q}_0 = \int_0^Q q_0 \, dG(q_0).$$

Defining of $P_{1s}$ is carried out by the statistical data. The table defining distribution of number of the located deep wells as seismic operations were realized is constructed. In the general form this table is in the following form:

| The member of located wells after the realization of seismic operations, $N$ |
|---|
| $n_1$ |
| $n_2$ |
| $n_3$ |
| . |
| . |
| . |

$$\Sigma n_1 + n_2 + \cdot + n_k = B .$$

Then value $P_s$ will be equal

$$n_1 / B = P_{1s} \; ; \qquad n_2 / B = P_{s2}, \; \ldots \; .$$

Let the data typical for the concrete deposit be given

$P_1 = 0{,}2$ ; $P_s = 0{,}7$; $S = 0{,}001$; $P_2 = 0{,}9$; $\hat{q} = 100$ ; $P_s : P = 3{,}5$ ;

$B = 1$ ; 0.5; 0,25; 0,125; 0,0625.

Using these data in design equations the following results were obtained

**Table**

| | $P = 0{,}7$ | $P = 10^{-3}$ | $P = 0{,}9$ | $P_1 = 0{,}7$ | $P = 0{,}7$ $S = 10^{-4}$ |
|---|---|---|---|---|---|
| $B$ | $bP_2 = 1$ | $S_0$ | $bP_2 = 1$ | $bP_2 = 0$ | $S_0$ |
| 1 | 11 | 5 | 9 | 18 | 15 |
| 0,5 | 15 | 4 | 14 | 26 | 14 |
| 0,25 | 23 | 3 | 20 | 40 | 13 |
| 0,125 | 33 | 3 | 30 | 59 | 12 |
| 0,0625 | 46 | 2 | 40 | 85 | 11 |

The given table contains the results on defining of the optimal amount deep wells locations and in accordance with this the value of seismic operations depending on the hydrocarbon volume is given. It is evident, that increasing of the probability of seismic operations $(P)$ sharply influences on reducing of the amount of located deep wells and the amount of seismic operations.

Consequently, the result shows that the realization of seismic operations plays a significant part for decreasing of expenditures at field development and its reserves extraction. So, the logical model allows to make decisions in all possible situations in uncertain conditions with the maximal profit of the engineering process.

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