Applying information technologies in identifying the features of deposit identification under conditions of different oil-and-gas provinces

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Abstract. This paper describes application of information technologies to reveal general regularities in target identification under conditions of various tectonic and stratigraphic elements from studying the influence of the volume of basic geological and field information onto the degree of identifiability of deposits. A minimal set of parameters has been established to characterize various geological system while conducting the identification procedure using a limited amount of information at the early stages of field development. An algorithm is proposed for determination of parameter weight to identify the parameters that have a prevailing influence on identifiability of development targets. A set of parameters that are neglectable due to various financial and organizational reasons has been established.

1. Introduction
Identification of targets in various business sectors allows solving a wide range of tasks aimed at increasing efficiency of management over various processes.

For example, in oil industry, the identification procedure allows:
- for deposits under development:
  - justifying correctness of development analysis; distribution of successful innovative technologies to similar targets in sought-for and neighboring oil-and-gas bearing regions; solutions aimed at reducing production costs; increasing the oil recovery factor; extension of operation for formations with hard-to-extract reserves; selection of testing grounds for advanced technologies;
  - determining causes of lower depletion of reserves;
  - selecting efficient technologies and their optimal parameters;
  - creating scientific and methodological foundation to justify efficient development of similar targets in the future;
  - selecting and using surrounding information for recovery of residue stocks;
  - determining trends in efficient use of investment and areas of efficient application of technologies;
using each target as a test bed for neighboring similar targets, with the aim of efficient use of both positive and negative lessons learned from its operation;

- reducing the risks of adopting inefficient solutions for further development of the production targets;

- significantly increasing the efficiency evaluation objectivity with respect to application of innovative technologies;

- determining a degree and nature of influence from both geological and technological parameters that consider the degree of oil recovery [1-6];

- monitoring development with revealing the causes of reduced development and finding methods for its increase; evaluation of prospective levels of technological indicators and possibility of applying secondary and tertiary recovery methods;

- performing search of information required for preparing design documents; expertise of obtained data and establishing its veracity using similar targets and, as a result, reducing the duration and increasing the quality of design works leading to acceleration of bringing the deposit into development;

- determining options for transferring stocks into viable reserves category and determining the efficient development strategy;

- reducing risk level and uncertainty when solving exploration and development problems; making optimization-related managerial decisions;

- timely reacting to changing insights about formations and processes, using empiric evaluations from other targets.

Resolving identification issues is of special importance in the Volga-Ural (VUOGP) and West Siberian (WSOGP) oil-and-gas provinces, where significant resources of oil and gas are concentrated in small and medium deposits pertaining to the hard-to-recover category and not currently involved into active development, as well as a large number of deposits having being under development for long and now containing a significant amount of hard-to-recover remaining oil in place. These stocks are a significant reserve for domestic oil production [7-10].

2. Methods and materials

There are a large number of works dedicated to resolving the issues in identification of development targets. For conditions seen in deposits in terrigenous reservoirs of the Volga-Ural oil-and-gas province, the most well-known and widely applied are the identification algorithms proposed by M.A. Tokarev, R.G. Abdulmazitov, R.G. Ramazanov; for deposits in carbonate reservoirs of VUOGP – V.Sh. Mukhametshin, I.I. Abyzbayev, N.Sh. Khayredinov.

For terrigenous reservoirs of West Siberia, the identification algorithms have been created by Sh.Kh. Sultanov, Yu.A. Kotenyov, V.Ye. Andreyev, V.V. Mukhametshin.

Analysis of the previously proposed algorithms revealed a number of aspects requiring elaboration and additional research.

The algorithms are based on using a different number of geological and technological parameters – from 13 to 35, at that, the set of parameters is different between different variants. However, the most critical is that the minimal number of parameters necessary for identification with a sufficient accuracy is undefined, which is of the highest importance when developing deposits at the very edge of their economic profitability. This important problem was solved for the algorithms described in works [11] and [12], for carbonate reservoirs of VUOGP and terrigenous reservoirs of WSOGP, respectively.

3. Results and Discussion

Studies of a degree of identifiability of research targets depending on the number of geological-physical and physico-chemical parameters of formations and their fluids was performed by analyzing the percentage of correctly grouped targets at each step of removing the least significant parameter from
consideration. The least significant parameter is the one that may be removed with minimal change in correctly grouped targets, as compared to other parameters at the same step.

Generalization of the results has shown that the influence of the parameters characterizing geological-physical and physico-chemical properties of formations and their fluids, mode of occurrence and pressure-temperature conditions onto identifiability of targets varies under various conditions. At that, significance of the parameters during the identification is largely defined by the emergent nature (integrity) of the system, implemented in correlation between the parameters characterizing the system. If two parameters show a strong correlation and one of them is among the most significant, the second is then relegated to the category of less significant, thus, allowing for a significant reduction of parameters used for identification. The analysis revealed parameters having a prevailing influence over the identifiability of development targets under various geological and field conditions; a set of common parameters has been defined ensuring a 70% identifiability of deposits.

Using the proposed formula:

$$J = \frac{\sum_{i=1}^{n} R_i / n}{n}$$

where J is information content of a certain parameter when determining the percentage of correctly grouped parameters; R_i is the rank number in the i-th variant of target grouping; N is the number of grouping variants that include the parameters, it has been established that the most informative parameters, in the decreasing order, are:
- \(H_E\) - effective oil-saturated thickness of formation (J = 0.33);
- \(K_{perm}\) - permeability coefficient (J = 0.56);
- \(H_{occ}\) - depth of occurrence of the formation (J = 0.76);
- \(m\) - porosity coefficient (J = 0.88);
- \(K_{SSR}\) - sand-to-shale ratio (J = 0.92);
- \(\mu_P\) - viscosity of formation oil (J = 1.06);
- \(K_P\) - oil saturation coefficient (J = 2.33).

In contrast, from the point of view of uniqueness and being included into various variants, the distribution is somewhat different (in the decreasing order):
- \(H_{occ} = 5\);
- \(K_{perm} = 5\);
- \(\mu_P = 4\);
- \(m = 4\);
- \(H_E = 3\);
- \(K_P = 3\);
- \(K_{SSR} = 3\).

However, it should be noted that these parameters are a minimum that shall be available when identifying and grouping deposits of the Volga-Ural and West-Siberian oil-and-gas provinces. At the same time, a list of parameters having insignificant influence onto the percentage of correctly grouped targets; these parameters may be neglected if absent due to various causes, including organizational and financial ones.

4. Conclusions

Thus, application of information technologies to studying features in oil deposit identification under varying conditions of different oil-and-gas provinces in both carbonate and terrigenous reservoirs confined to different stratigraphic horizons allowed obtaining the following main results and coming to certain conclusions:

1. It has been established that the degree of influence of parameters characterizing geological-physical and physico-chemical properties of formations and their fluids, mode of occurrence and pressure-temperature properties onto identifiability of deposits varies depending on underlying conditions.
2. Parameters having a prevailing influence over the identifiability of development targets under various geological and field conditions have been revealed; a set of common parameters has been defined ensuring a 70% identifiability of deposits.
3. A formula for parameter significance has been proposed and used to determine most significant parameters and rank them in the decreasing order for identification and grouping of development
targets: effective oil-saturated thickness, permeability coefficient, depth of occurrence, porosity coefficient, viscosity of formation oil, oil saturation coefficient.

4. A list of parameters having insignificant influence onto the percentage of correctly grouped targets; these parameters may be neglected if absent due to various causes, including organizational and financial ones.

5. A minimal set of parameters has been established to characterize various geological system to conduct the identification procedure using a limited amount of information at the early stages of oil field development.

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