

Advantages of the Petroleum System Concept

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Abstract – Unique hybrid modeling technology of hydrocarbon migration allows to create a detailed high accuracy model, based on complex physical transformations. This technology assures the most accurate solution of the main modeling problem, dependency between the competence of geological record and inrush of the sealing horizon. It also far exceeds methods that are based on flow pattern of the fluid by Darcy's law.

Key words – hydrocarbon system modeling, borehole, geological model, geological survey, maturity, oil and gas windows, seismic inversion, trap.

I. Introduction

Since 1994 there has been a huge increase in the amount of publications dedicated to the problems of hydrocarbon system modeling. At the same time the total number of the references to the term “hydrocarbon system” in the scientific literature has reached 2400 [1]. Besides, the modeling of hydrocarbon system has become the integral part of the geological survey in the Western countries long time ago. In this paper the main advantages of using the petroleum system concept during the search for presence of oil-and-gas in the hydrocarbon basins of the world is considered.

II. Methodology

For a long time, researchers have relied on the constant idea about the structure of the sedimentary layer of the crust during the search for hydrocarbon reservoirs. It means, that rocks and the structures they create — anticline trap, were the main components for the search. This approach gave eligible results, but did not give the main answer — how to predict the place in the basin, where there are hydrocarbons and where there are no hydrocarbons. Attempt to give the answer to this question generated plenty of the theories about oil and gas origins, but today there is only one working concept that allows to “see” where and when the hydrocarbons were formed and what was their development path. Although, the main advantage of this concept is that it gives the answer to the sacramental question — in which part of the crust you need to look for the hydrocarbons, what will their properties be and what amount of the hydrocarbon crude can be taken from the discovered deposits.

In the last decades petroleum system concept has become the integral part of the geological survey in the Western countries, but, unfortunately, it is has not been used in Ukraine.

The petroleum system concept is the relatively new branch of the geology; it was formed in the 80s and got its theoretical design in 1994.

This theory considers cumulative connection between mother rocks, reservoir rocks, cap rocks, possible traps and the processes of formation, migration and accumulation of the hydrocarbons. The consideration of these processes is the main difference of this concept.

The petroleum system concept is one of the most unique in the modern concept of geological knowledge. On the one hand, none of the surveys in the Western countries is performed without hydrocarbon system model; on the other hand, it is not used in the Eastern countries, including Ukraine.

The analysis of hydrocarbon systems begins on the entry levels of the survey. It is performed after the general construction of the geological model of the basin, but it should precede the general survey of promising deposits. Properly speaking, the model of the hydrocarbon system should give information about the perspective availability of hydrocarbons in some trap.

The first step in creation of the model is one-dimensional modeling along the borehole. It allows to get the history sedimentation model, pressure and temperature regime model along the well bore as well as to estimate the potential amount of the hydrocarbons, which formed out of source rocks. Advantages of this model are high accuracy and correlation between the borehole data [2]. On the other hand, it describes the geological environment only in one point of the basin.

Further steps are constructions of 2D and 3D models along the lines with boreholes, in which 1D seismic was used. The example of the large-scale 3-dimensional model is the model of North German basin [3]. The area analyzed is 812x528 km or 400 square kilometers. The pantry picked is 4x4 km. Based on the results of modeling, the gas line trend was selected. It allows predicting the laying of new boreholes [3].

The analysis of the geotectonic factor helps to estimate the probable evolution of the temperature regime and predict the degree of maturity and depletion of mother rocks. Temperature is the main factor that influences the formation of so called oil or gas window — moments when the generation of the hydrocarbons starts and finishes (Fig. 1).

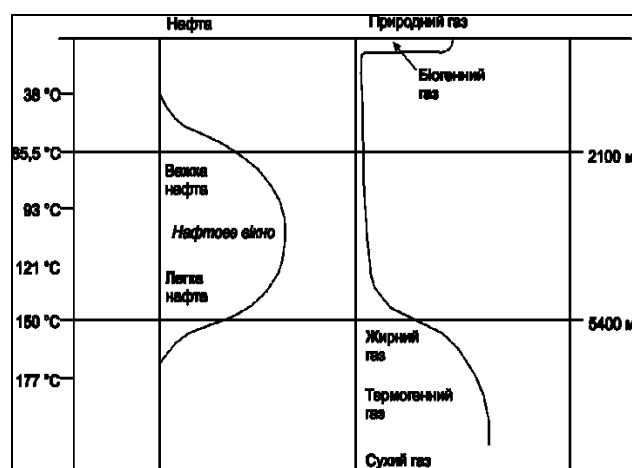


Fig. 1. Oil and gas windows. Formation temperature of the hydrocarbons [5]

This way most of the oil from the mother rocks generates in the temperature span from 65.5 °C to 170 °C. In case of higher temperatures the generation of gas begins. At 170 °C oil is destroyed [5].

Apart from the borehole and laboratory data, that is traditionally used, the results of seismic inversion give a high efficiency during the modeling of hydrocarbon systems. The inversion allows to get the distribution of the main petrophysical properties of rocks and as a result more accurately predict the properties of “between the borehole” environment during the process of setting main parameters for the model.

The main advantage of hydrocarbon system modeling is the ability to reduce the risks during drilling boreholes. Determination of the time, when hydrocarbons were generated, their types and main rocks that can be the catcher for hydrocarbons allows not only to calculate the potential of the territory and correctly predict the amount of hydrocarbon crude, but to optimize the complex of geological survey methods.

It is traditionally thought, that hydrocarbon system modeling is used on the pre economical phase of survey. We can't get the information, which companies could use to create economical report or to declare the income from these models. Besides, the narrowing of the area gives opportunity to economize time and financial resources. Thus, it makes the search for hydrocarbons economically profitable.

On the other hand, relying on the traditional data, we can use the results of the geological study to restore the history of the basin or areal distribution of the main rocks, but we can't correctly predict their properties in general through the whole basin. Nowadays, most of the models rely on the borehole data first of all, although the analysis for the areas of hundreds of thousands square kilometers will have relatively large error. To avoid this and to increase the precision of the models new technologies are created. They will help to use seismic data to define the physical properties of the rocks and their correlation with the borehole data. This research is excessive during the regional modeling, but it is vital for the hydrocarbon potential analysis of the small poorly explored areas.

Different criteria and factors can be taken to create the hydrocarbon accumulation model, but we suggest using the list of factors, that will help to establish the development strategy and to optimize economic indicators of the deposit:

- Reconstruction of the plunging history considering the thickening of the rocks.
- Modeling of the heating history.
- Local processes modeling such as oil generation and primary migration, carbonation and formation of the induced porosity etc.

- Hydrogeological modeling of the sedimentary basins.
- Secondary migration and hydrocarbon accumulation modeling.

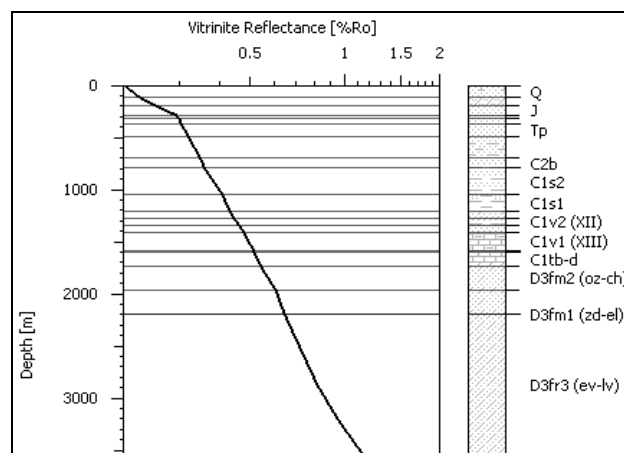


Fig. 2. Vitrinite reflectance

Conclusion

Modeling of the hydrocarbon systems gives opportunity to form and verify the clear sequence of hypothesis that help to estimate the gas-bearing prospects as well as the type of rocks, their depth, thermal history, quality of the mother rocks, slop systems etc. Due to the accurate analyzes distinct formulation of the problem helps to establish the key parameters and estimate the possible risk for predicted prospective areas. In this case, modeling is a tool for oil exploration. Modeling provides the integration of all data (sedimentological, thermal, geochemical, hydraulic, and structural) tied between each other.

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