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Conceptual geological modeling as a basis for the development of carbonate deposits in the Middle East region

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Abstract. When working with carbonate deposits, taking into account the geological features of their structure is necessary to understand the change in the dynamic properties of the formation at the beginning of the development. It helps to implement the most effective strategy from the selection of well types and to the identification of promising drilling zones. In this paper, an algorithm is presented to identify the main geological factors that have a significant influence on the approaches to field development and the confidence in production forecasting. An example is considered of the approach of LLC Gazpromneft-NTC to the study and prediction of properties by the example of one of the Middle East fields. This approach to modeling a complex carbonate field made it possible to obtain a conceptual geological and hydrodynamic model of the field. The created dynamic model increases the accuracy of the prognosis of the productivity of new wells and confirms high prognostic abilities following the results of drilling.

Keywords: geological concept, well productivity, carbonates, Mauddud, Zagros

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Introduction

The task of predicting the productivity of wells in carbonate reservoirs is always associated with high uncertainties due to the influence of many factors on reservoir properties of rocks both during sedimentation and during subsequent secondary transformations of the structure of the void rock formations.

The paper considers an example of the approach of the company Gazprom Neft Science and Technology Center to study and predict properties on the example of one of the fields in the Middle East. The main productive object is the Upper Cretaceous Maudud formation, 8 strata are distinguished within this formation (A, B, C, D, E, F, G, H) (Saad Z. Jassim, Jeremy C. Goff, 2006).

The deposits of the upper layers of the object under consideration (A, B, C) are sustained in area, have low variability of reservoir properties, which allows to predict the thickness and properties of rocks, the average error of the predicted thickness does not exceed 4%. The lower part of the formation (D, E, F), on the contrary, demonstrates the high heterogeneity and variability of reservoir properties in terms of area and vertical, which entails the need for facies and/or cluster analysis in order to improve the quality of the forecast.

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The purpose of this work was to create a factual basis for confident prediction of the productivity of new wells.

Respectively the following tasks were solved:

- identification of the main drivers of rock conductivity for each of the strata of the formation;
- creation of the concept of geology;
- selection of a method for predicting the lateral distribution of properties in accordance with it.

Gazprom Neft Science and Technology Center has developed and successfully applied a standardized algorithm for working with carbonate reservoirs when analyzing data. it includes the analysis of petrographic studies, work with core data, interpretation of Wed and, as a result, the creation of a conceptual geological model (Idrisova et al., 2018).

The analysis of petrography includes an assessment of the genetic reasons for the formation of void space, the numerical determination of the degree of influence of secondary processes on the properties of the rock. The use of this approach in our case was complicated by a number of limitations in the initial data – secondary processes manifested in the rock are described at a qualitative level, there is no quantitative assessment.

It is worth noting a small number of core samples from non-key reservoirs; the strata B (145 samples) and D (510 samples) are most fully represented. In total, the core was extracted from three wells, with a total penetration of ≈148 m with a reservoir thickness of ~ 400 m.

Lithological study of core. Evaluation of the role of secondary transformations

The pore space is represented by both intergranular and intragranular porosity, the presence of microfractures and dolomite crystals is noted (Fig. 1).

In order to assess the impact of structural (sedimentation) rock characteristics on reservoir properties, a comparison of the number of “grains” in thin sections was made with measurements of the porosity coefficient on cylindrical samples taken at the same points as the thin sections (Fig. 2). There is a trend of increase in the porosity of the rock with an increase in the ratio of grain/cement. Accordingly, the restoration of the sedimentation situation for the area under consideration implies an understanding of the most likely trend of property distribution over the area.

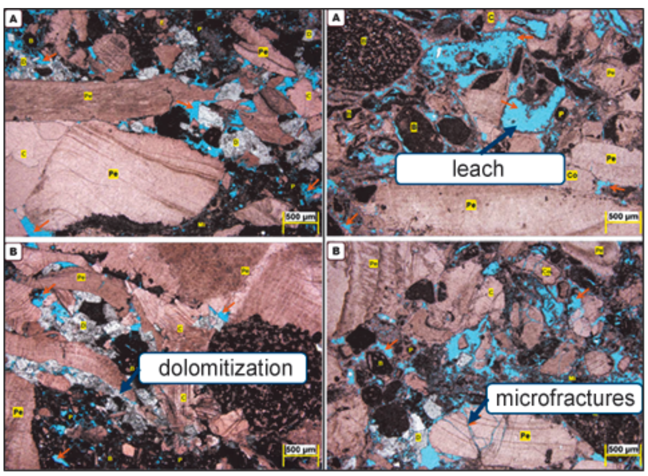

Fig. 1. Examples of thin sections

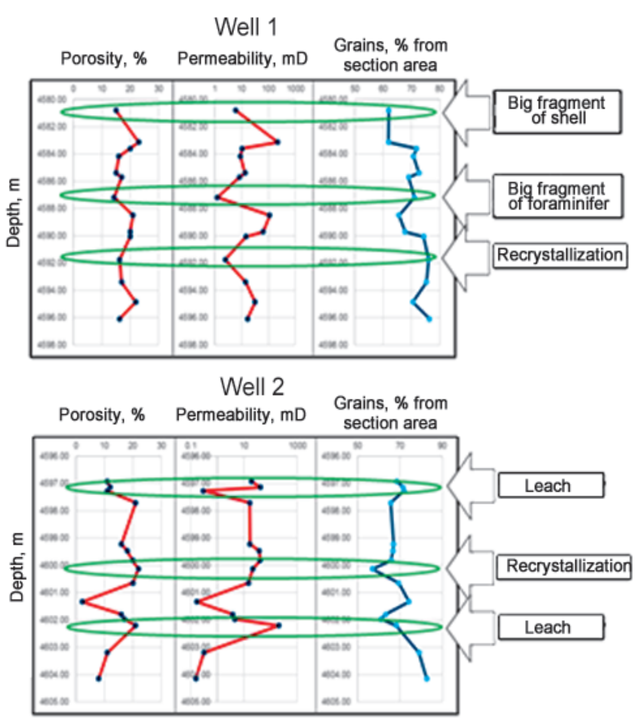

Fig. 2. Connection of primary sedimentation signs of rocks with their porosity

For some samples, the graphs show deviation from the selected trend. the main reason is the manifestation of secondary processes in the rock. Due to the lack of quantitative determination of the degree of their manifestation, conclusions were made at a qualitative level.

The visual study of thin sections of the D formation most clearly manifested dolomitization and leaching of the rock. If the first one had a negative impact on reservoir properties, then leaching affected positively. Secondary transformations probably took place in rocks with already good reservoir properties and due to leaching, improving the quality of the pore space. In zones with initially low reservoir properties, solution penetration was difficult, and in such rocks secondary transformations did not have such a serious impact.

Creating a conceptual geological field models

Based on the general description of the core, as well as conclusions from the data of petrographic analysis, the sedimentation situation – the carbonate ramp – with rudist structures within its limits was restored (Fig. 3).

In accordance with the accepted concept, the correlation of the selected reservoirs was made by wells (Fig. 4).

According to the analysis of seismic data (spectral decomposition, Fig. 5a), zones for the development of anomalies are distinguished. Based on the conclusions about the conceptual structure of the layers, these anomalies are most likely to be zones of growth of organogenic structures (rudist reefs), which are characterized by increased filtration properties.

The analysis of hydrodynamic and field geophysical studies showed a significant difference in the filtration properties of the section.

The strata A, B, C (upper part of the section) are sustained along the section, however, they have permeability several times lower than the D and E

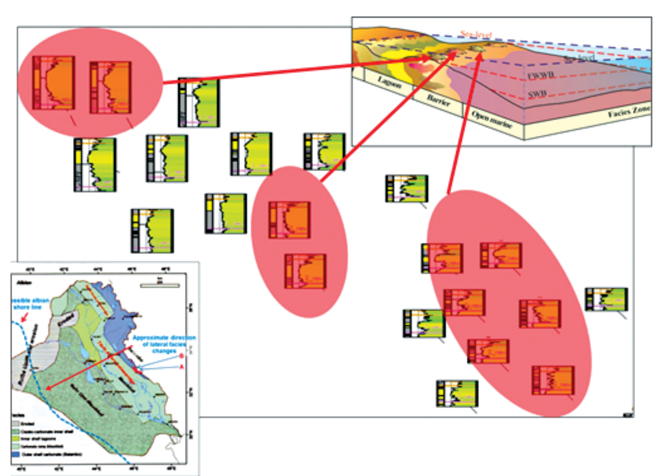

Fig. 3. The concept of the geological structure of the field (the areas of potential growth of organogenic structures are highlighted in color)

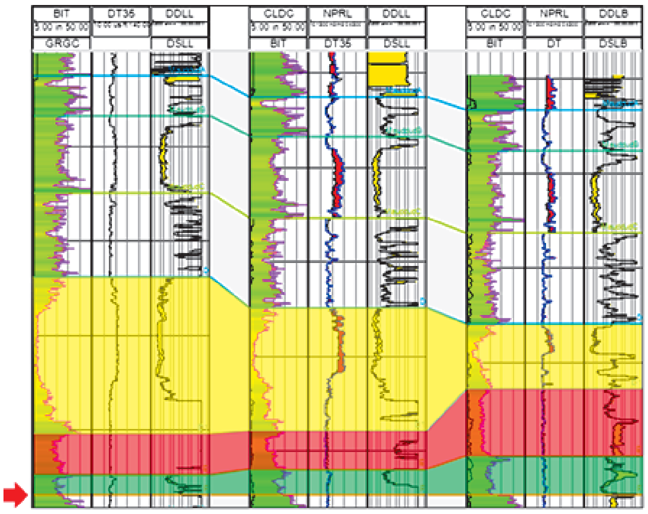

Fig. 4. An example of a reservoir correlation scheme (to the cross-strike)

layers, which is probably due to the smaller effect of the leaching process on the rock.

A comprehensive analysis of all types of data (core, logging, hydrodynamic studies, field geophysical tests) also showed that natural fracturing is weakly expressed and does not significantly affect the productive characteristics.

The results of the analytical work were used to create a geological model of the reservoir, which was then transferred for dynamic modeling.

During the analysis of seismic data, a relationship was established between the zones of cavernous development in the rock (confirmed by well data) and the attribute map of maximum amplitudes (Fig. 5b). This map was used as a trend in the distribution of the permeability field in the interwell space (Fig. 6). The approach used allowed us to obtain a good combination of the actual and model parameters of the dynamic model and did not require the use of additional settings (factors of permeability, productivity, etc.).

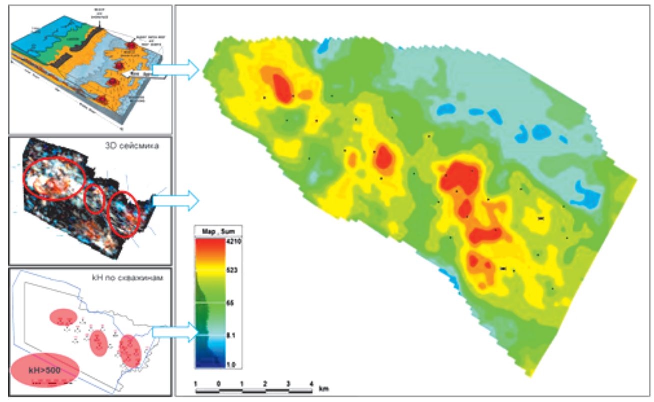

Fig. 6. The final map of the reservoir conductivity

Conclusions

A cross-functional approach to modeling a complex carbonate field allowed us to obtain a conceptual geological and hydrodynamic model of the field.

The created dynamic model increased the accuracy of the forecast of the productivity of new wells and confirmed the high predictive abilities based on the results of drilling.

The results obtained are recommended for replication when modeling other carbonate facilities of the company.

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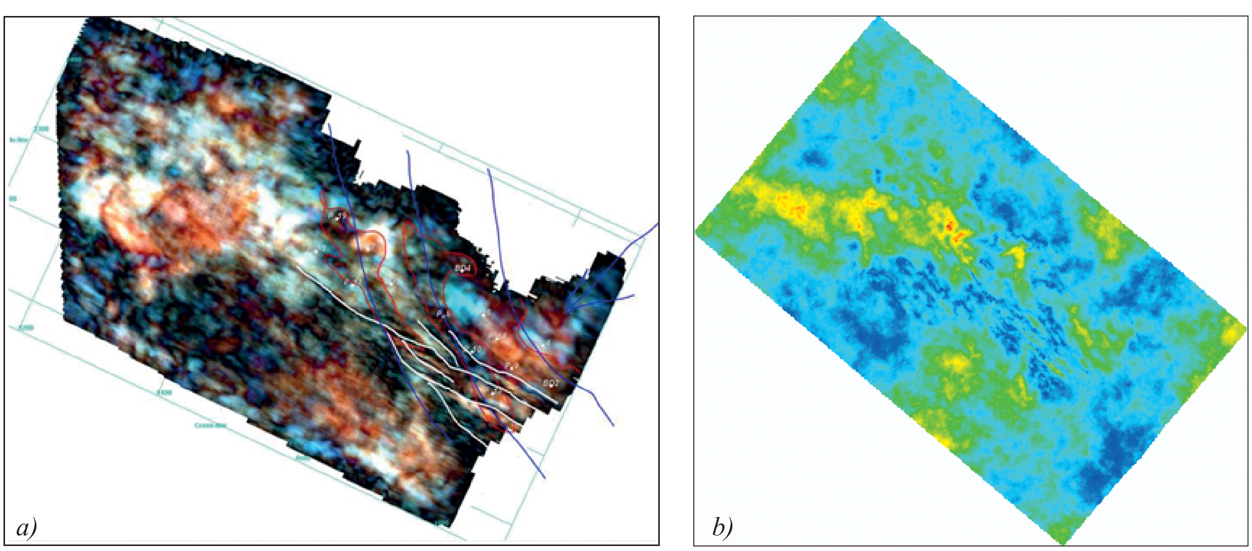

Fig. 5. Spectral decomposition

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