SEDIMENTOLOGY AND DIAGENESIS OF UNIQUE LOWER CRETACEOUS "VANKOR-TYPE" SANDSTONE RESERVOIRS IN WESTERN SIBERIAN BASIN

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The Lodochnoe oil and gas field is a part of the Vankor hydrocarbon deposits group in the northwest of the Krasnoyarsk region. According to oil and gas geological regionalization, it belongs to the Bolshekhetskiy oil and gas-bearing region of the Pur-Tazovskaya oil and gas provinces of the West Siberian Basin. Group method application of data handling for Vankor field geological modelling theme was review in Antonenko et al. [1] and Semenov et al. [2], though now, there are a number of problems associated with taking into account the facies features of the oil-bearing layers formation and their subsequent diagenetic transformation [3]. Goncharov, Oblasov et al. [4, 5] described fluid composition and oil biodegradation. Nevertheless, there is no method for predicting filtration characteristics based on an integrated sedimentological approach has been proposed before. The studied reservoir is multi-layered; the main hydrocarbon reserves are confined to the Lower Cretaceous sandstones. Laboratory studies of the core material selected on the Lodochnoe deposit territory are carried out in the analytical centre of the Tomsk oil and gas research and design institute.

Sedimentary facies identification with the sandstone material composition study [6] in investigated deposit is necessary to identify the oil-bearing sandstones heterogeneity causes and improve the forecasting and modelling accuracy of the deposit's layers structural features [7]. The comprehensive sedimentological research [8] related to the terrigenous rocks study commonly includes material composition analysis, depositional environments identification and diagenetic transformation stages definition [9]. Increasingly, these studies are supplemented by precision methods: electron microscopy [10], X-ray diffraction analysis [11]. Currently micro porosity study in thin sections as an integrated approach is also considered as well as the methods stated above together with using specialized equipment and programs [12].

The core samples morphological texture (laminations) analysis is one of the most important stages of the core layered macroscopic description, it allows to reveal a number of relevant features, reflecting the processes and formation sediments conditions. The data conjunction about the sandstone laminations features, their material composition in thin sections, and the certain trace fossils presence with floral and faunal remains in the rock allow us to accurately determine the sedimentary environment [13]. Based on the facies association we can assume the presence of a particular sandstone body form. The particle size distribution of clastic grains, their compaction, and shape affect the primary sandstone porosity. However, in the diagenetic transformation process the rock composition and sandstone porosity-permeability characteristics can be greatly changed. Secondary changes description and tracking in sandstones allows us to explain their structure heterogeneity. Moreover, finding patterns between the data on the core samples permeability [14] and their lithological characteristics makes it possible to bring the field model closer to the real complex geological situation. Based on all of the above, the authors have developed a complex sedimentological technique based on the data of studying core material, petrographic samples, sandstones porosity and permeability, and the material composition peculiarities using precision methods.

Two main sedimentation environments were caused the formation of two productive sandstone layer types. Productive medium- and fine-grained, predominantly with well-sorted material sandstone layers of the Nizhnekhetskaya suite were formed on the barrier coast in bars crest and central parts. Oil-bearing fine- and medium-grained, predominantly medium-sorted sandstones in the Malokhetskaya, Sukhududinskaya and Yakovlevskaya suites were formed in the distribution channels of the delta system with a predominance river influence. Considering these factors in sequential stratigraphy will make it possible to correctly determine the sandstone body shapes in the process of well data correlation. Petrographic and X-ray diffraction analysis showed that, in sandstones with a high content of metavolcanic clasts and interlayers enriched with biotite, the main diagenetic transformation process is chloritization. At the same time, for rocks with a high content of feldspars, diagenetic kaolinite is more characteristic. Diagenetic siderite is most developed in sandstones with a clayey interlayer's high content. The feldspars dissolution and pore kaolinite cement formation had a positive effect on permeability. The low degree of grains compaction made it possible to draw conclusions about the effect of active tectonic movements on reservoir properties in the form of secondary deconsolidation processes in sandstones. Authigenic calcite in general negatively affects the reservoir characteristics. Nevertheless, calcite dissolution (partial or complete), became the reason of local sandstones layers with diagenetic improved porosity formation. In such case locally, carbonate dissolution contribute to the reservoir formation [15].

The determining role in the formation of the porosity - permeability relationship was played by the cement mineral composition, its content and the way of filling the space. To take into account the contents of the main cement types in the porosity - permeability dependences plotting, the authors selected correction factors reflecting the degree of influence of a certain cement on the "lithological" porosity of the rock. Apparently, the validity of the use such coefficients stems from the significant effect of a finely dispersed clay aggregate on the ability of the rock to filter gas or liquid. A number of regularities at this stage of research have been characterized quite unambiguously, since the formation of kaolinite aggregates in the pore space of sandstones made it possible to preserve the pore space in sandstones at the stage of their diagenetic transformation. In addition, weak positive effect of small (up to 15%) contents of calcite cement on porosity was revealed, it can be assumed that this is due to the formation of secondary porosity in carbonate sandstones; however, an accurate interpretation has not yet been obtained. The authors plan to study the remaining issues related to the accurate interpretation of lithological data in subsequent works. In general, there is a trend to improve permeability with increasing the grain size. Trend offset is associated with diagenetic carbonatization, chloritization, and kaolinitization in pore space (Fig.10). Based on the assumption about the influence of the composition and content of the cementing part on the permeability of productive sandstones, the coefficients were empirically selected to assess the degree of influence of each of the lithological parameters on the permeability. And combining them into one formula made it possible to evaluate the totality of their influence, based on the values of the coefficient of accuracy of the approximation.

In the formula below: K is the sandstones porosity determined by helium, K is the porosity corrected by lithological features, and C is the cement content as a percentage of the area of the petrographic thin section. A = 0.78 ... 1.04 - an empirical correction factor connecting the weighted average diameters of grains and pores, asymmetry and kurtosis of pore size distribution. The coefficient is selected individually for the well, taking into account the quality of the thin sections and the degree of cementation of the sandstones.

$$K_{lithological} = (K_{porosity\ He} - 0{,}32 \cdot C_{kaolinite} - 0{,}75 \cdot C_{illite} - 0 \cdot C_{chlorite} + 0{,}13 \cdot C_{calcite}) \cdot A$$

The graphs shows that kaolinite, illite and calcite had the greatest impact on reservoir properties. In quantitative terms, their contribution to the formation of "effective" porosity of sandstones is established. Thus, the correction for the content of kaolinite in the pore space made it possible to correct the correlation coefficient on the porosity - permeability plot for sandstones in the Lodochnoe deposit by 5%, the content of illite by 4.5%, and calcite by 2%. Correction for the ratio of the average grain size to the average pore size made an adjustment of another 1%. Taking into account the above-mentioned corrections that correct the values of the total porosity to obtain effective values, the porosity-permeability R-squared value was 0.97 (Fig.1), which confirms the correctness of the approach chosen by the authors.

The authors tried to find the relationship of as many lithological parameters as possible with permeability. The main assumption was based on a model with the simplest possible structure of the pore space (model with balls of the same size), when the porosity has a clear exponential dependence on permeability. In real natural reservoirs with granular porosity, there is a partial deviation from this model and the dependence becomes less pronounced. In this case, it would be more correct to speak not about general, but about a kind of "lithological" porosity. For example, variations in size towards the predominance of smaller pores will lead to an increase in the role of the effect of surface tension on the grain surface and, as a consequence, to a decrease in permeability. To convert the total porosity to "lithological", the ratio of the weighted average grain and pore sizes was used. In most cases, this ratio was slightly more than unity and varied within 1-3, i.e., usually the pores were slightly smaller than the grains that form them. Nevertheless, the ratio often reached 5-8, which was explained by the presence of a large number of relatively small pores resulting from the destruction of detrital grains (for example, dissolution of feldspars) and during crystallization or dissolution of the cementitious material in the pore space (for example, the formation of kaolinite cement).

In addition to the obvious effect of the pore size on the permeability, a significant effect was found on it of the pore distribution parameters - asymmetry and kurtosis - with almost complete absence of the effect of standard deviation (sorting). Based on the results of a comprehensive study, it can be argued that the high permeability of the Lower Cretaceous sandstones in the Pur-Taz oil and gas region is associated with regressive dia- and metagenetic processes of their transformation. Therefore, the secondary decompaction, dissolution of feldspars, the formation of microporosity inside the kaolinite cement significantly improved the reservoir properties of the rocks. Conversely, intense secondary carbonatization reduced the permeability of individual interlayers and contributed to the formation of local seals. The obtained data on lithological grounded modeling of the dependence of porosity on permeability will be used in the future in geological modeling.

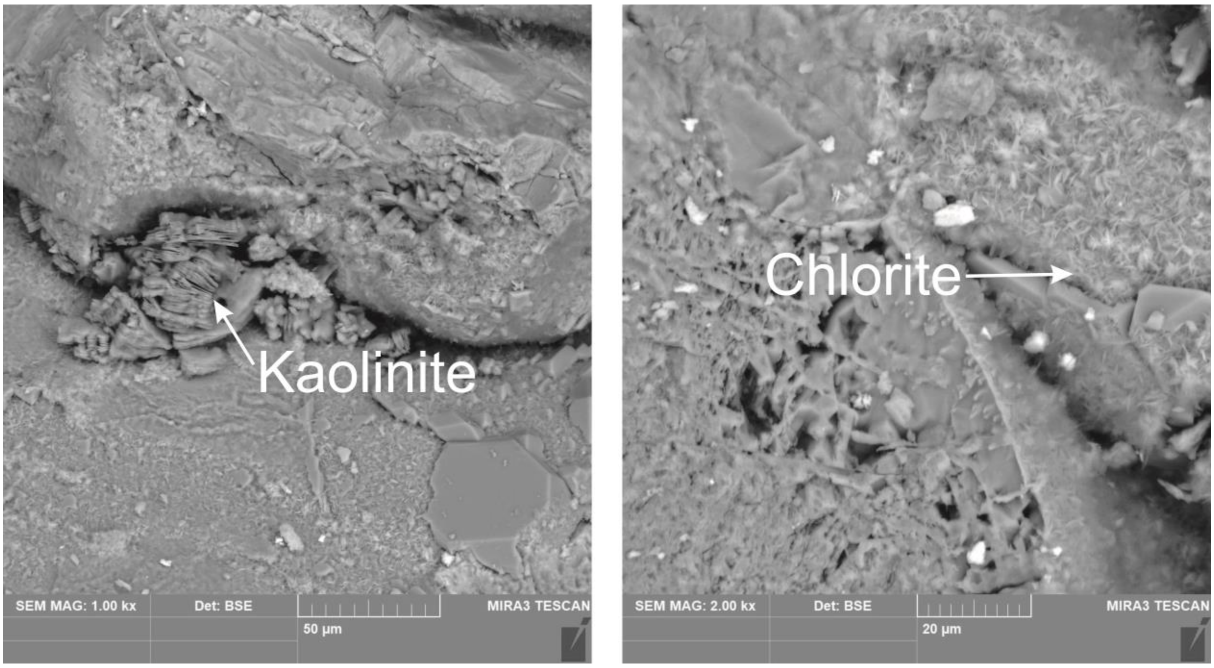

Fig.1 SEM images: on the right part – kaolinite packs, on the left – chlorite flakes ordered distribution in sandstone cement indicates its diagenetic origin

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STRUCTURAL AND TECTONIC PREREQUISITES FOR THE FLOODING FORMATION IN THE SELENGA RIVER VALLEY, REPUBLIC OF BURYATIA

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Purpose of the work: determination of factors and forecast of flooding and underflooding of a rural settlement in the valley of the Selenga River.

The urgency of the problem of underflooding and flooding of the urbanized territories of Eastern Siberia lies in the fact that their intensity and scale increase, which entails large economic and social problems associated with various types of losses: settlements, agricultural land and even human.

Flooding is a formation of a free surface of water on a site as a result of an increase in the level of a watercourse, reservoir or groundwater.

Underflooding is a complex hydrogeological and engineering-geological process in which, as a result of changes in the water regime and the balance of the territory, an increase in the level of groundwater occurs, leading to disruption of economic activities in the given territory [1].

Underflooding caused by different reasons is observed in many cities all over the world, including the USA, Great Britain, France, Germany, India, Kazakhstan, China, Korea, etc. In Russia, underflooding takes place in many built-up areas of the European part of the country, the Urals, the Far East, and Siberia.

The built-up areas in the south of Eastern Siberia are extremely subject to underflooding. The reasons are diverse: disastrous snowmelt floods, leaks from the old underground utilities, failures of the storm sewage systems, and a barrage effect of the deep foundations of civil engineering structures with underground parking lots.