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Hydrocarbon Systems and Estimation of the Probability of Discovery of Oil and Gas Accumulations in the Bering Sea

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Abstract. The results of studying the hydrocarbon systems with application of the modelling techniques using the Schlumberger PetroMod software complexes are considered. Modeling of sedimentary basins of the Bering Sea and their hydrocarbon systems is performed. Estimation of the probability of discovery of oil and gas accumulations related to the marine hydrocarbon systems showed that the highest probabilities of the discovery characterize the GAHS correspondent to the Eocene-Miocene (Mainitsky-Sobolkov) sediments. Probabilities of discovery of the deposits within the younger Gagarin-Avtatkul hydrocarbon systems (Lower to Middle Miocene) are substantially lower. The perspectives of discovery of oil and gas accumulations are related to oil and gas generation and accumulation capacities of insufficiently studied and distributed along the area of the deep-water region Cretaceous-Cenozoic or more ancient sloping deep sea sedimentary complexes, total capacity of which is higher in the northern and eastern near-slope zones of the Aleutian basin comprising 6 to 8 km or more. Studying of the above complexes would apparently facilitate a substantial increase of total hydrocarbon potential of the Bering Sea.

1. Introduction

On the basis of studying of oil and gas geological properties of the ground-based sections in the margins and boreholes, Cretaceous, Paleogene and Neogene sediments, the share of which according to the estimation accepted at that time, amounted to 27, 30 and 47 % correspondingly of the potential of its initial total resources, were determined as the perspective oil and gas producing complexes in the Bering Sea confined to the near-Pacific OGPR by the beginning of 1980s. Most of the volume of the sedimentary mantle of the Russian part of the Bering Sea shelf is formed of Cenozoic sedimentations including all the elements of active hydrocarbon systems explored in the region, to which all the found in this region industrial scale accumulations of the resources are related.

2. Research methods

The geochemical and lithological researches were conducted in order to study the hydrocarbon systems, and the modeling techniques using the Schlumberger PetroMod and QGIS software complexes were applied. Small-scale modeling of the sedimentary basins in this region and their hydrocarbon systems was performed [1]. A series of the required structural constructions, lithological-paleogeographic and paleodynamic reconstructions and other specific researches allowing determining of



the boundary conditions for the modeling; was performed in the process of preparation of the input data necessary for performance of the modeling procedures. Estimation of the probability of discovery of oil and gas accumulations related to the marine hydrocarbon systems is performed on the basis of the known methods for estimation of the perspective objects [2].

3. Research results

The prognosis for distribution of potential Paleogene and Neogene oil and gas producing rocks made as the result of research and modeling (Figure 1) showed that the oil and gas producing rocks within sedimentations of the age concerned, which are developed within the continental mainland and continental margin (transitional) complexes of the parts of the OGPR, possess a smaller area as compared to its seaward territory that is the central and eastern troughs of the sedimentary basin [3].

The terrigenous rocks of the Tanyurer horizon having the porosity values from 5.1 to 15.1% and within the Yagelny sequence – from 3.4 to 18.1%; possess the reservoir rock properties within the Paleogene stratigraphic interval. Generally, the sediments of Upper Eocene-Oligocene have low reservoir rock properties [4], [5]. However, the sandstone rocks with the porosity of up to 17.3%, and the sandstone rocks of the upper Mainitsky formation within the Echin area attaining the porosity of 27.8 % can be found in the sections of development of the Ust-Chirynay formation. Sandstone rocks and tuffaceous rocks of the Sobolkov horizon and included into it Lower Miocene formation with the same name are characterized by the porosity values of predominantly 6.3 to 21.7%. Maximum values of porosity within the sediments of the Lower Miocene amount to 28.8...33.4%, whereas their highest values are typical for the sediments of the Gagarin formation. With occurrence within the middle and upper parts of the Miocene section (Avtatkul and Telekai horizons) of large-grain and well sorted sandstone and gritstone rocks, the number of granular reservoir rocks improves – their porosity varies from the minimum of 4.0...16.6% to the maximum of 29.4...42.1%.

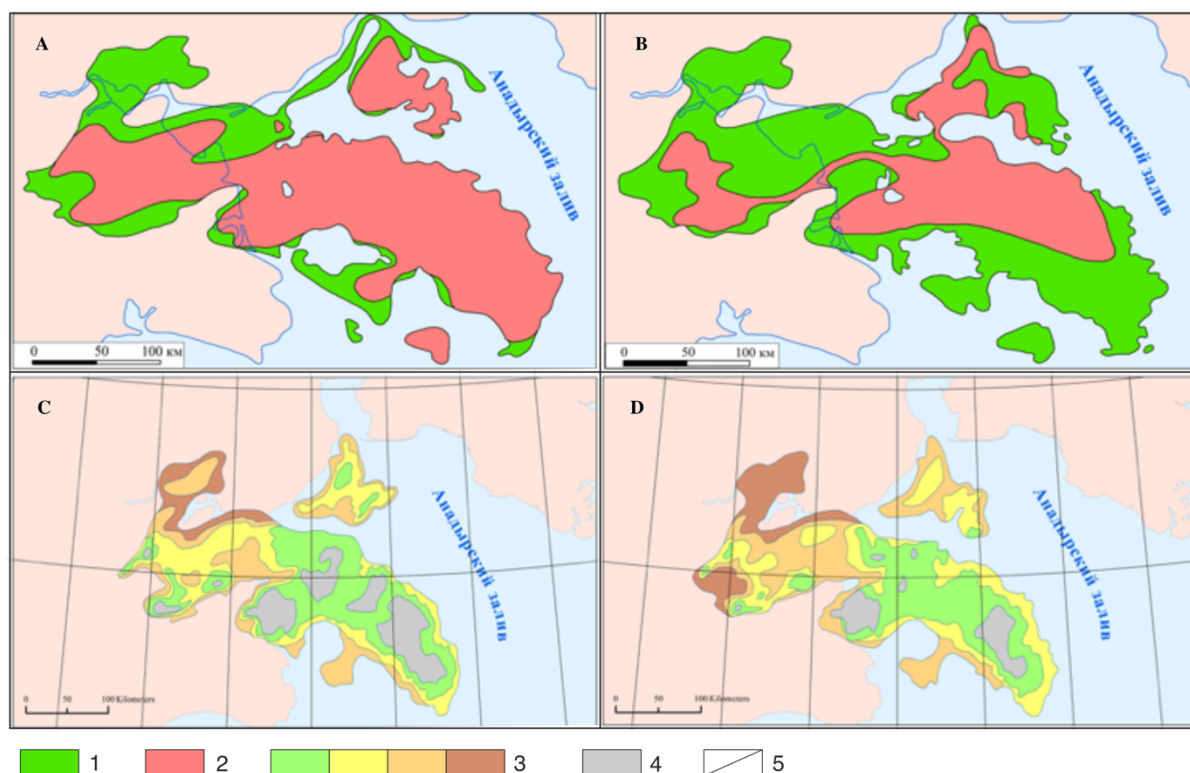


Figure 1. Block diagram of distribution of potential oil and gas producing rocks (A – Eocene-Miocene (Mainitsky formation), B – Lower Miocene) and the porosity of the reservoir rocks (C – Lower-Miocene sediments (Sobolkov horizon and its analogs), D – Middle-Miocene sediments (Avtatkul

horizon and its analogs) of the Anadyr OGPR on the basis of the modeling results (generalized). 1 – distribution domains of the fascies possessing no oil and gas producing capacities; 2 – distribution domains of the potentially oil and gas producing rocks, 3 – porosity, %; 4 – the domain of absence of the predicted high-porosity reservoir rocks; 5 – coastal line.

Total 12 types of rocks containing the strata of sandstones, sands and gritstones with good reservoir rock properties can be separated within the Cenozoic sediments; four of which are related to the Paleogene sediments and eight – to the Neogene interval possessing the best reservoir rock properties [6].

The distribution of the reservoir rocks within the boundaries of the Anadyr OGPR (Figure 1) predicted on the basis of modeling results shows that sediments of the western continental mainland and continental margin zones of this region are characterized by a higher porosity as compared to its lying more eastwards offshore parts. This prediction forms no contradiction to the results of drilling of the only in these waters Tsentralnaya-1 offshore well, which results show total decreasing of the effective porosity of the sediments as compared to the continental mainland territories of the sedimentary basin [7], [8].

Characterizing distribution of the fluid traps it should be noted that powerful and having lengthy strikes fluid traps were not revealed in the Paleogene and Miocene sediments on the continental mainland of the Anadyr OGPR. Terrigenous sediments of the bottom parts of the Mainitsky formation and the strata of the argillites and solid sandstones of the Miocene can be regarded as local covers [9]. In the offshore part of the region, the analogs of the Eocene-Oligocene Mainitsky horizon existing in the continental mainland can be represented as the regional fluid traps within the Paleogene section. Distribution of the fluid traps of different quality possessing the opal-cristobalite composition is typical for the Miocene section within the offshore part of the region [10].

The prognosis for the OM maturity levels of the oil and gas producing rocks in Anadyr OGPR (Figure 2) performed in the process of modeling of the hydrocarbon systems on the basis of the results of studying the strata temperatures and reflecting properties of the vitrinite in the wells drilled on its continental mainland, showed that all the potential oil and gas producing rocks attained the maturity, which was sufficient for generation of the hydrocarbons, within the most submerged sections (troughs) of the sedimentary basin bearing the same name [11]. In this case, the degree of OM catagenesis of the Eocene-Oligocene oil and gas producing rocks is not generally exceeding the generation stages of the primarily fluid hydrocarbons. Whereas, the potential of the Miocene oil and gas producing rocks attained the level of the “oil window” on comparatively small in terms of area sections of the oil and gas bearing region (see Figure 1). Generally speaking, the most submerged sections (troughs) of the Anadyr sedimentary basin, in which the mature oil and gas producing sedimentations are located; can be regarded as the potential centers for hydrocarbon generation.

Small and medium in terms of the reserves fields – oil Upper Telekai, oil and gas condensate Upper Echin and gas West Ozerny are discovered in the Miocene sediments of continental mainland of the Anadyr oil and gas producing rocks. Small ingresses of oil and gas in the wells and the surface seepages were detected within the sediments from the Upper Cretaceous to the Miocene including the igneous (magmatic) rocks [12], [14]. Based on the results of drilling of the Tsentralnaya-1 shelf well the industrial scale hydrocarbon potential was not detected in the shelf territory of the region.

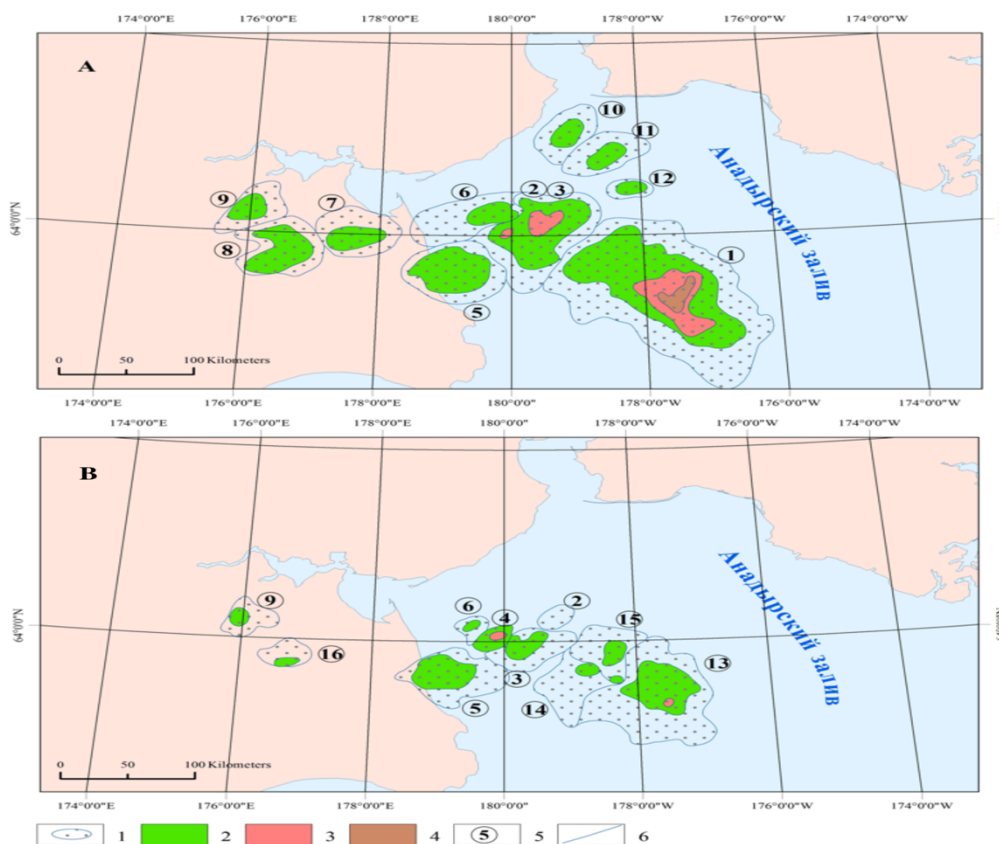


Figure 2. Predicted generation and accumulation hydrocarbon systems (GAHS) of the Anadyr OGPR on the basis of the modeling results (generalized): A – Eocene-Lower Miocene, Mainitsky-Sobolkov sedimentations, B – Lower-Middle Miocene, Gagarin-Avtatkul sedimentations.

1 – GAHS development area, 2 – region of the predominant oil generation in the center, 3 – region of the predominant gas generation in the center, 4 – overmature rocks development area, 5 – GAHS index, 6 – coastal line. Encircled numbers (GAHS): 1 – East Anadyr, 2 – North Nikolaevskaia, 3 – South Nikolaevskaia, 4 – West Nikolaevskaia, 5 – Lagoonal trough, 6 – Solomatinskaia, 7 – Oleninskaia, 8 – Mainitsky trough, 9 – Velikorechenskaia, 10 – Uelkal, 11 – Kurim, 12 – Enmelen, 13 – Koryak, 14 – South Chukchi, 15 – North Chukchi, 16 – Protochny trough

4. Conclusion

The hydrocarbon systems within the Paleocene-Lower Miocene part of the sedimentary section are different in terms of their areas and dimensions of the generation center, and correspondingly, in terms of the volumes of the produced hydrocarbons. The Nikolaevskaia Mainitsky-Sobolkov GAHS is the most promising one. All the Lower and Upper Miocene hydrocarbon systems of the Gulf of Anadyr are characterized with a low degree of realization of the generation potential of their OGPR that is stipulated by a low maturity of the organic matter of the rocks concerned. Estimation of the probability of discovery of oil and gas accumulations related to the marine hydrocarbon systems showed that the highest probabilities of discovery (basically 0.167 to 0.189) characterize the GAHS, which are correspondent to the Eocene-Miocene (Mainitsky-Sobolkov) sedimentations. The probabilities of discovery of the deposits in younger – the Gagarin-Avtatkul – hydrocarbon systems (Lower and Middle Miocene) are substantially lower, amounting to 0.135...0.162. The potential of the undiscovered recoverable resources within the Russian part of the Bering Sea, according to the official estimation accepted by the Ministry of Natural Resources and Environment of the Russian Federation (MPR of Russia) as of 01.01.2009, amounts to 894 million tons of the oil fuel equivalent, the

composition of which is comprised by the gas resources for about 68%. However, it should be taken into consideration that these numbers disregard the oil and gas producing and accumulating capacities of quite poorly studied and distributed along the deep-water region Cretaceous-Cenozoic or more ancient sloping deep water sedimentary complexes, total producing capacity of which within the northern and eastern parts of the near-slope zones of the Aleutian basin may comprise, as it is shown above, 6 to 8 km or more. Studying of the above complexes would apparently facilitate a substantial increase of total hydrocarbon potential of the Bering Sea.

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