Relationship of inversion tectonics and oil and gas potential within the Northern part of West Siberia

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Abstract. The paper presents the results of paleo-tectonic reconstructions of the formation features of Jurassic-Cretaceous deposits in the northern part of the West Siberian sedimentary basin, based on the method of constructing the isopach triangle. The paleo-tectonic reconstruction carried out served as the basis for creating a tectonic dislocation scheme for the Mesozoic-Cenozoic sedimentary cover of the northern part of West Siberia. The degree of tectonic dislocations is justified by the authors in this paper as one of the criteria for oil and gas content within the studied area. Thus, the designed scheme can be used to identify new and promising oil and gas potential areas and expand the hydrocarbon resource base in West Siberia.

1. Introduction
To date, to maintain a high level of oil and gas production, it is necessary to ensure a constant increase in the resource base of hydrocarbons. This is achievable only when carrying out a wide range of geological exploration. Taking into account the fact that most of the stock of un-drilled large anticlinal traps was exhausted to this day, the issue of identifying new oil and gas bearing criteria which can be used in the practice of geological exploration is acute.

In this paper, on the basis of paleo-tectonic reconstructions, the factor of the tectonic dislocation of the sedimentary cover is justified by the authors as one of the new criteria for oil and gas bearing within the northern part of West Siberia. The basis for identifying this criterion is a unique process of tectonic development of the northern part of the West Siberian oil and gas province, due to Triassic rifting. The existence of a massive system of rifts led to a frequent change of descending and ascending tectonic movements in the Jurassic-Cretaceous period, which contributed to the formation of "weakened" sections of the earth's crust favorable for migration and accumulation of reservoir fluids, including oil and gas.

2. Formulation of the problem
The main task set by the authors is the identification and subsequent mapping of areas with a high degree of tectonic dislocation, as well as the identification of their relationship with oil and gas content within the northern part of the West Siberian oil and gas province, which will allow us to justify the degree of tectonic dislocations as the most important criterion for the oil and gas potential of the studied area.
3. Results and discussion

3.1. Analysis of the paleo-tectonic development of the north of West Siberia

During the Mesozoic and Cenozoic stages of tectonic development, the northern part of the West Siberian Plate was a region of stable submersion accompanied by the filling of a sedimentary basin with terrigenous rocks [1, 2]. The deposit and development of the rift system in the Triassic led to the fragmentation of the earth's crust and the emergence of a series of inter-rift blocks, to which the largest and most high-amplitude uplifts are assigned in the deposits of the sedimentary cover. Within their boundaries, the Jurassic incisions are reduced in relation to the adjacent rift depressions. In the Cretaceous, both the rifts and the inter-rift areas were intensively submerged. In this connection, in their limits more powerful sediments were accumulated than on stable blocks distant from the rifts [3, 4]. In this case, the deposit of tectonic structures controlling oil and gas fields occurred in the late Jurassic – early Cretaceous time. Subsequent tectonic and neo-tectonic movements of the Mesozoic and Cenozoic times caused the structures transformation, determining their morphology, sizes and amplitudes.

At various stages of the development of the sedimentary basin, the periods of intense deflection were repeatedly replaced by the stages of uplift, which is reflected in changes in the thickness of the sedimentary complexes and in the displacements of the boundaries of the basins and uplifts. At the same time, changes in vertical tectonic movements were caused by the block structure of the pre-Jurassic complex. Such a change in the direction of tectonic movements during geological time is called tectonic inversion, which in plain language is manifested in the change of the anticlinal forms of the paleo-relief to synclinal and vice versa.

According to M.Ya. Rudkevich and other researchers [5, 6, 7] it was the inversion of the tectonic movements that took place during the formation and development of the sedimentary cover which exerted a decisive influence on the structure of anticlinal structures controlling the deposits of multi-layer oil and gas fields and on the oil and gas content of the northern part of West-Siberian plate as a whole.

3.2. Construction of a tectonic dislocation scheme

To assess the influence of alternating tectonic movements on oil and gas potential in the northern part of West Siberia, the authors developed a scheme for the tectonic dislocation of the Jurassic-Cretaceous part of the sedimentary cover. The construction of this scheme was carried out on the basis of combining the results of seismic studies and data of prospecting drilling. The authors made regional structural maps of the scale 1:500000 on the sole of the sedimentary cover, as well as the roofs of the Middle, Upper Jurassic, Neo-Aqom, Aptian, Cenomanian and Turonian deposits. Based on the data obtained by the method of V.B. Neiman [8] a set of isopach maps was developed, which characterizes the accumulation of precipitation in the Jurassic, Neocomian, Aptian, Albion, Cenomanian and post-Cenomanian times. Then the isopach maps were renormalized in the range from -1 to +1. The first number corresponds to the most deeply submerged sections of the paleo-basins, and the second corresponds to the paleo-uplifts of the positive structures.

In the next step, all the transformed maps were sequentially summed, divided by the number of additions. As a result of the implemented transformations, a scheme was obtained which characterized the general orientation of tectonic movements in the Jurassic-Cretaceous stage of tectonic development of the northern part of the West Siberian plate. In this case, the maximum positive values of the integral parameter correspond to the areas where the uplifting
processes of the territory prevailed, and the minimal ones correspond to the areas of immersion. The values of the parameter close to zero (from 0.1 to +0.1) correspond to the areas of inversion development characterized by the most frequent change of signs of tectonic movements in the course of development of the sedimentary basin. There are these areas which are characterized by the maximum degree of tectonic dislocation in the Mesozoic stage of the area development.

3.3. Relationship between oil and gas content and tectonic dislocations
Analysis of the distribution obtained (Figure 1) indicates that most hydrocarbon deposits discovered in the northern part of West Siberia tend to sites with the maximum degree of tectonic dislocations of deposits of the sedimentary cover. These include Kharasaveyskoe, Krusensternskoye, Medvezhye, Yamburgskoye, Urengoiyskoye, Yuzhno-Russkoye and Kharampurskoye deposits. About 60% of the geological reserves of gas, gas condensate and oil found in the Yamal-Nenets Autonomous District are concentrated within these areas.

Figure 1. Map of the tectonic dislocation of the Jurassic-Cretaceous part of the sedimentary cover.
Localization sites of the Malyginskoye, Yuzhno-Tambeyskoye and Severo-Tambeyskoye giants deposits correspond to the values of the integral parameter, varying in the range of values from -0.2 to +0.2. These deposits are referred to areas characterized by an average degree of tectonic dislocation of sedimentary cover rocks. Under the same conditions, the Zapolyarny dome-shaped uplift developed, which controls the giant gas field of the same name.

The imposition of multidirectional vibrational motions, which conditioned the deposit, development and reformation of both positive and negative structures, makes it possible to assume the conjugacy of the plicative structures with disjunctive dislocations. The linear orientation of the areas with the maximum degree of tectonic dislocation of the Mesozoic part of the sedimentary cover, observed at the junction sections of the northern part of the West Siberian plate with the Siberian platform and folded formations of the Urals, and also within the Nadym-Pur-Taz interfluve, is most likely due to disjunctive dislocations. The northwestern and north-north-western stretch of disjunctive disturbances is a characteristic reflection of the fold-forming tectonic movements within the northern part of the West Siberian plate, which is reflected in the character of the area spread and the extent of the riftogenic areas.

Manifestations of disjunctive tectonics at various stages of formation of the sedimentary cover, accompanied by activation of more ancient tectonic disturbances of the pre-Jurassic complex, conditioned the limitations of large structural elements of the relief, vertical and horizontal displacements along the fault surfaces, thereby determining the features of sedimentation and thickness of sedimentary complexes, as well as their stretching and crushing in the folds. As a result, there was the emergence of linearly oriented sedimentary structures and the articulating cavities as well as intermediate structures.

The change of signs (directions) of tectonic movements also caused the renewal of the previously formed fault system. As a result, disjunctive dislocations spread upwards along the section, covering the basement rocks and deposits of the sedimentary cover, presumably up to the day surface.

Estimating the oil and gas control role of the factor of tectonic dislocations, it is necessary to note the following. The inverse nature of the development of the West Siberian sedimentary basin which caused frequent changes in ascending and descending tectonic movements, caused fragmentation and disruption of sedimentary rocks, resulting in the formation of areas of macro- and micro-cracking. The tectonically weakened zones were areas preferable for vertical jet migration of reservoir fluids, accompanied by the movement of oil and gas during the filling of the traps.

4. Conclusion
The nature of the area distribution of giant gas fields, as well as the majority of oil and gas fields, indicates that within the northern part of the West Siberian plate the parameter of the tectonic dislocation of the Jurassic-Cretaceous part of the sedimentary cover can be considered as a predictive criterion for localizing hydrocarbon deposits in the prospecting process for oil and gas. The tectonic dislocations scheme developed by the authors justifies the most promising areas for further geological exploration, which can include the central part of the Gydan Peninsula, the southwestern part of the Yamal Peninsula, and the peripheral part of the north of the West Siberian oil and gas province.
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