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To cite this article: A I Tseplyaeva 2015 *IOP Conf. Ser.: Earth Environ. Sci.* **27** 012019

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Perspectives of oil and gas presence in pre-jurassic sediments on the example of one West Siberian deposit

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Abstract. Conducted geological and production researches were reviewed and methods in determining excessive fracturing for mapping and geological model of the pre-Jurassic complex traps were proposed. The volume of fractured rocks in the calculation of reserves was taken into account. The work on mapping of oil and gas bearing potential of the pre-Jurassic complex on the territory of research was performed.

1. Introduction

Current problems of petroleum geology are conditioned by the development of oil- and gas fields with complex geological structure. High drilling cost and, therefore, a limited number of wells require risk reduction at the stage of searching, fieldwork and initial stages of development. Study of complex structure reservoirs in conditions of sediment accumulation, specific to Krasnoleninsk arch, makes it necessary to study and represent the details of geomorphological structure of different trap types sufficiently and accurately, and, simultaneously, to create an initial geological model. Recently, more and more attention is being paid to the regularities related with genesis and oil and gas deposit placement which earlier was neglected by many oil and gas companies [1].

These deposits are related to crystalline sedimentary and metamorphic rocks, on the one hand, and magmatic and effusive rocks or crustal weathering, on the other hand. Despite high prospectivity and potential, the interval of this geological column is still poorly studied, particularly in Western Siberia. There are a number of objective reasons being "constraining" factors in successful prospecting, exploration and development of such deposits.

It is believed that there are no sufficiently up- to- date proved methods and methodical solutions in estimating the physical fields in magmatic rocks, which reflect fractured areas for oil and gas accumulation. To determine the reservoir development zones (fracture, cavern, structural porosity) and their porosity and permeability properties and saturation behavior, there are practically no appropriate study methods and interpretation techniques of geophysical well logging data.

There are still debates on a number of geological aspects related to the oil source, its migration and accumulation, nature of typical to deep depth factors and processes [2, 3].

2. Petroleum potential of the territory

The subject of the study is one field in West Siberia, where oil deposits were discovered related to the crust weathering and Paleozoic, to Jurassic formations, and also to Lower Cretaceous Vikulovsk suite. The oil and gas horizon reaches more than 1000 meters. Geological structure, effective mapping methods for potential oil and gas bearing sites furthers their active involvement in the field



development. There are three structural levels within the profile: lower- undivided folded metamorphic Proterozoic-Paleozoic; medium – intermediate Triassic sequence; higher –Mesozoic-Cenozoic sedimentary mantle. Mesozoic-Cenozoic oil and gas bearing complex embraces UK2-5 productive layers of Tyumen suite and VK1 composed of Lower Cretaceous Vikulovsk suite. The deposit is located within the Uvat-Khanty-Mansi median massif, confined to Krasnoleninsk arch within Baikal folded area, being altered by Hercynian tectogenesis. Investigated area is confined to the structures of deuterio-orogenic development stage -superimposed depressions and anticlines within median and resistant massifs, Baikal fold – horst complexes. Oil and gas bearing content has been found in the sediments of Vikulov, Tyumen, and Pre-Jurassic formations [4].

3. Geological and geodynamic analysis

Investigated area is in the initial development stage, stage of increasing petroleum extraction. The project sites under development are related to sediments of Vikulovsk and pre-Jurassic formations. It is the project site Pz, associated with pre-Jurassic sediments (crust weathering and Paleozoic sediments) that is of interest in terms of exploration methods and the mapping of its potential productive areas, in terms of creating a non-trivial approach to reservoir modeling and to estimation of its reserves, as well as development methods

Pre-Jurassic basement includes Paleozoic metamorphosed rocks, mainly crystalline schists (garnet-amphibole, amphibole, amphibole-biotite and biotite-quartz-feldspar, two-mica, quartz-feldspar, chlorite) and amphibolites. There are also local areas composed of gneiss (mica, quartz-feldspar, and rarely, hornblendes). There are no distribution patterns in the cross-section -but only alternating ones. The degree of rock weathering decreases with depth.

3D seismic data interpretation results and drilling data indicated that oil deposit locations are confined to local basement protrusions with deep discontinuous disturbances, which could control blind localized flows and hydrocarbon fluid flows [2]. Commercial oil and gas accumulations are confined to multiple activated system of disjunctive dislocations, formed at the early stages of formation consolidation, whereas recent geological activities still continue to influence this process. Enhanced reservoir areas are associated with areas of maximum fracturing within the activity zone of young or renewed faults, through which deep hydrothermal solutions contribute to the formation of decompacted zones. Carbonization along cracks could be observed.

The research has shown that rock porosity and permeability according to core samples change within a very small range. Porosity coefficient changes from 0% to 15%, while permeability coefficient from 0.001 mD up to several mD, as observed in a number of samples. The cap rocks, reservoirs and disjunctive dislocations interlinking with geodynamic activity constitute favorable conditions for oil and gas formation [1]. It is assumed that the primary factor determining the location of hydrocarbons in low-permeability formations is the secondary formation of their reservoirs, usually fractured, cavern and mixed types [3].

According to the geological, geophysical and field information analysis, the identified oil deposits in the investigated area is the fact that their current geometrization is rather arbitrarily. First of all, this concerns oil-water contact (OWC) because in adjacent wells water-saturated intervals have not been exposed, so OWC is conventional. Consequently, there is no edge water. Based on the results of formation testing and well performance dynamics, sharp oscillatory variations of well flow rates were registered ranging from a few hundred to zero cubic meters per day.

Above-mentioned characteristics may indicate the relation between the structure and productive intervals, and zonal morphology with excessive tectonic fracturing; while density of hydrocarbon reserves in different deposit areas involves secondary cavities. According to V.I. Popkov [3], characterizes this deposit type as “vein type”.

Morphology of pre-Jurassic reservoir complex (including the investigated area) is mainly determined by tectonic fractured areas confined to basement ruptures and protrusions. Therefore, within the framework of set tasks, secondary reservoir development zones and their potential is to be evaluated in order to map the oil and gas deposits in low-permeability rocks, and to identify the most

potentially productive areas and zones. Firstly, geophysical, geomorphological and remote-sensing methods are applied and secondly, direct methods are used providing information about the influence of deposits on geophysical and geochemical fields [3]. The data on field fracturing of the geological environment are obtained on the basis of both ground and complex well geophysical investigations, where, seismic acoustic methods are predominate.

Detecting and determining the configuration of fracture zones via tectonic models are used to identify fracturing as a result of complex stress-strain environment, are being made. There is evidence that demonstrate extremely uneven development of rock fracturing in the sedimentary mantle and on the deposit territory forming subvertical zones embracing basement rocks of the whole sedimentary complex. [3-5].

Recently, when mapping fractured areas, special seismic methods are being used (three-component data recording and scattered waves), correlating the intensity of the fracturing activity and one of the seismic parameters (amplitude of duplex waves) [6]. Based on such correlations permeability values in boreholes are determined. Distribution of permeability field reflects the distribution nature of the amplitudes of duplex waves within the investigated areas and deposits, providing a clearer idea about the features of zone distributions with higher permeability.

3D-seismic survey was conducted in this area, thus project potential assessment and oil-and-gas bearing potential were considered, including attribute maps calculated in seismic cube. The attribute map of root-mean-square amplitudes in the slot below the reflector A (roof pre-Jurassic basement) was used to geometrize deposits related to excessive fracture zones. The earlier works conducted in nearby areas proved that this attribute is effective for geometrization of deposits in pre-Jurassic complex. The areas of enhanced reservoirs, related to the areas of excessive fracturing within the zone of activity of young or renewed faults, confined to the most significant basement protrusions, were detected as a result of a comprehensive analysis of 3D-seismic and well test data and of dynamics of well performance (figure 1).

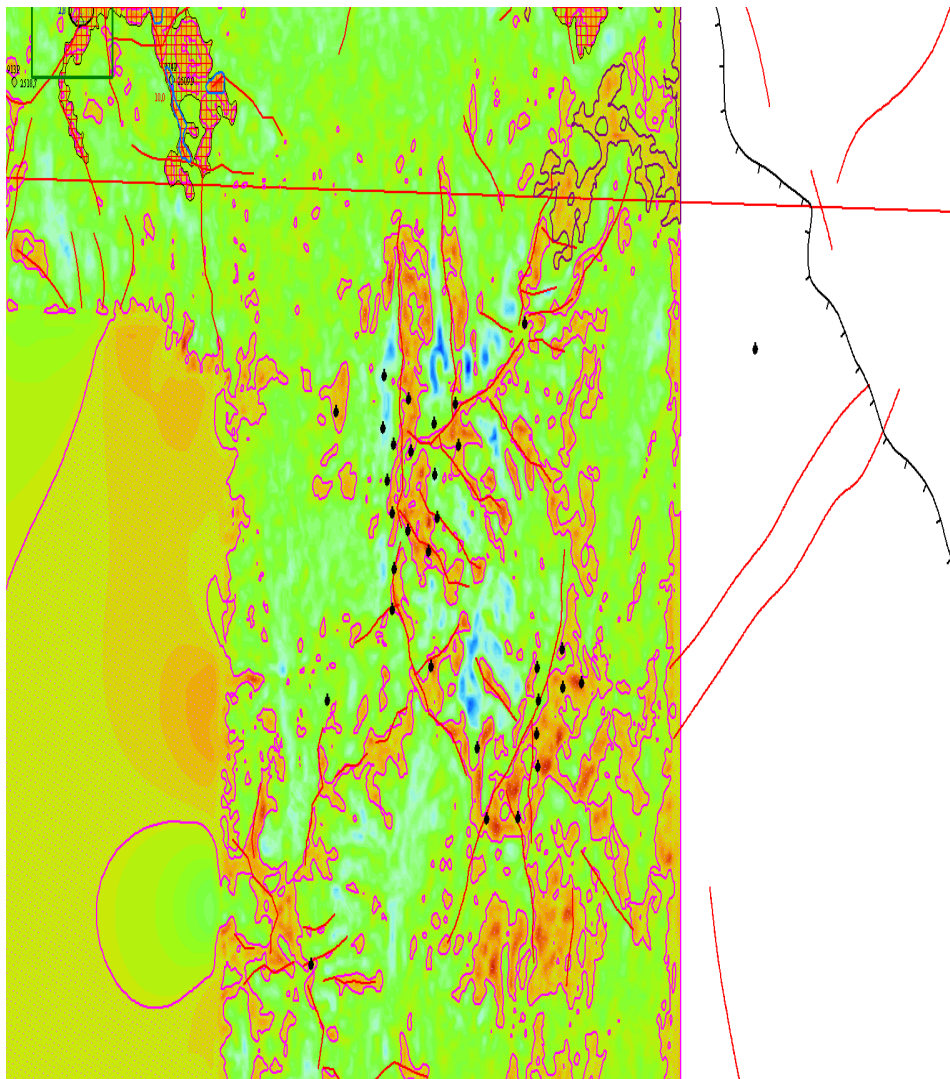


Figure 1. RMS amplitudes attribute map in the slot of 0-70 ms below the reflector A.

4. Conclusions

Evaluation of geological reserves volume in such project sites may be significantly underestimated if excluding the intervals of fractured rocks in well columns in geometrization via volumetric method. There are no officially recognized methods of estimating reserves in such areas with pronounced fractured elements.

It is suggested to include volume of fractured rocks when calculating oil reserves as an alternate solution of the problem. As a result, the volume of geological oil reserves has increased several percent units to the volume of fractured rocks. It is recommended to construct horizontal wells in a path of development of the detected enhanced fracture zones in order to develop such areas effectively. In addition, in this case, an obvious way to involve the highest volume of fractured rock around the well into development is to use hydraulic fracturing, which definitely increases the coverage even if the hit to fracture zones is imprecise. Basing on a comprehensive analysis of 3D-seismic, well test, well log survey and core sample data, areas of enhanced reservoirs, related to the areas of excessive fracturing were detected. Recommendations for well location and further field development were given.

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