Theoretical principles of petroleum hydrogeology of the West Siberian megabasin (WSMB)

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Abstract. Comprehensive study of the chemical and gas composition, temperatures, levels, pressure of deep underground water in deep wells is associated with the beginning of the systematic development of the oil and gas potential in Western Siberia and the first discovery of large deposits here. The development of new branches of hydrogeology is due to the fact of more and more available data. Thus, fundamental understandings of the WSMB hydrogeological conditions are being translated into new theories. Geodynamically, the WSMB structure was revised and based on hydrogeological data, regional and local prediction of oil and gas occurrence exploration criteria were developed. Based on the dispersion halo water-dissolved substance theory, exploration methodology of "neglected" deposits were formulated, conceptual issues of technogenic changes of oil and gas hydrogeosphere areas were being developed.

1. Introduction

Comprehensive study of the chemical and gas composition, temperatures, levels, pressure of deep underground water in deep wells is associated with the beginning of the systematic development of the oil and gas potential in Western Siberia and the first discovery of large deposits here. The development of new branches hydrogeology is due to the fact of more and more available data. Thus, fundamental understanding of the WSMB hydrogeological conditions are being translated into new theories. Geodynamically, the WSMB structure was revised and based on hydrogeological data, regional and local prediction of oil and gas occurrence exploration criteria were developed. Based on the dispersion halo water-dissolved substance theory, exploration methodology of "neglected" deposits were formulated, conceptual issues of technogenic changes of oil and gas hydrogeosphere areas were being developed.

2. Materials and methods

Fundamental concepts of petroleum hydrogeology are reflected in the works of A.A. Kartsev, V.N. Kortsenshteyn, G.M. Suharev, L.M. Zorkin, M. I. Subbota, L.N. Kapchenko, S.B. Vagin, V.M. Shvets, E..A. Bars, Yu.P. Gattenberger, A.R. Ahundov, A.M. Nikanorov and many others. Thanks to V.A. Sulin works in hydrogeochemistry (1935, 1948), petroleum hydrogeology was developed as a separate branch.

As petroleum hydrogeology developed, numerous regional scientific schools were being established, including the Siberian School. The representatives of the latter are A. Antsiferov, R.N.

Abdrashitova, M.B. Bukaty, A.I. Vozhov, V.P. Danilova, A.A. Dzyuba, L.A. Kovyatkina, A.R. Kurchik, O.I. Leuhina, V.M. Matusevich, D.A. Novikov, E.V. Pinneker, A.G. Plavnik, R.G. Prokopeva, B.P. Stavitsky, N.F. Chistyakova, S.L. Shvartsev, O.V. Shiganova and others. This article mainly highlights the contribution of Tyumen and Tomsk research school representatives to the petroleum hydrogeology theory

3. Research target

Comprehensive study of the chemical and gas composition, temperatures, levels, pressure and flow rates, organic matter and microflora of underground water in deep wells is associated with the beginning of the systematic development of the oil and gas potential in Western Siberia and the first discovery of large deposits here. The groundwater impact on the deposit formation and destruction and its energy is widely discussed, as well as interaction impact of formation and injection waters, their impact on rock porosity and permeability, their colmation. Researchers are considering technogenic hydrogeosphere transformation.

4. Background information

The forerunner of petroleum hydrogeology in Western Siberia is the outstanding scientist-hydrogeologist A.M. Ovchinnikov. In 1959 at the first hydrogeological meeting he outlined hydrogeochemistry and paleohydrogeology significance in mineral exploration and introduced the water drive system classification. In the 60's A.A. Kartsev published the first summary papers on petroleum hydrogeology.

As late as the 50's of the last century a number of works were devoted to the WSMB hydrocarbon potential assessment based on published hydrogeological data, including O.V. Ravdonikas, N.M. Kruglikova, V.F. Nikonova, A.A. Rozina, B.V. Mavritskiy. The hydrogeochemical indicators of hydrocarbon potential are regarded in details by N.N. Rostovstev. The most turbulent period of petroleum hydrogeology development is observed in the 60-80's as well as the industrial boost.

A.E. Kontorovich (1963), B.P. Stavitsky (1964), V.M. Matusevich (1966) summarized the chemical and gas composition of the groundwater trace elements in oil and gas regions of Western Siberia. Due to V.M. Matusevich large-scale research data in both ion-salt composition, and trace elements and water-dissolved organic matter of the deep horizons were obtained. The monograph "Groundwater Geochemistry of West Siberian Basin" presents unique data on water reduction-oxidation potential and experimental study of diffusion-osmotic processes.

Monograph, published in 1970, "Hydrogeology of the USSR. West Siberian Plain. Volume 16" with a series of maps, is still an indispensible guide on issues related to groundwater megabasin for scientists and specialists.

In the 80's fluid geodynamic concepts in the formation and development of WSMB water drive systems are becoming more and more popular among followers. Comparable to the artesian concept of the formation of deep groundwater horizons, V.M. Matusevich presented expelled water concept, explaining the composition and salinity difference, inversion and anomaly in WSMB.

A significant step in furthering above-mentioned concept was N.B. Vassoevich stages of petroleum generation. According to the theory of organic formation and petroleum accumulation, high trace element concentrations and organic substance in groundwater determine the main oil generation zone (MOGZ). It has been established that MOGZ has "floating" position in the cross section, its greatest depth is characteristic of the northern regions (5.5 to 4.5 km or more), and southward MOGZ intervals are mainly within the range of 2-3 km. This can be explained by the following factors: insufficient rock heating, thermal flux instability due to climatic variations in the Late Quaternary. The concept base and applying hydrogeothermal data to predict WSMB oil and gas occurrence via A.R. Kurchikov mathematical model has been presented in his monographs and scientific papers (co-authors; I.I. Nesterov, S.B. Stavitsky and others). A.R. Kurchikov monograph "Hydrogeothermal criteria of oil and gas occurrence" (1992) is of current issue today.

Accordingly to underground water geochemistry, petroleum generation and carbonification stages are regarded as organic matter transformation througout lithogenesis (V.M. Matusevich, V.K. Popov). In meso-catagenesis, not only organic matter conversion, but also groundwater interaction between host rocks and organic matter actively occur. In this case groundwater is significantly enriched by these components.

In the 80-s V.M. Matusevich revised hydrogeological stratification of WSMB cross section and identified three superposed hydrogeological basins with seven-level complexes. Later they were enhanced by the eighth level was identified as result of separating the Triassic and Paleozoic periods based on the deep well drilling data (V.M. Matusevich, 1984; V.M. Matusevich, L.A. Kovyatkina, 2013, 2014). According to this concept, sub-sequential member – West Siberian megabasin (WSMB) was identified, being a complex system of independent hydrogeological Cenozoic, Mesozoic and Paleozoic basins. Seven hydrogeological complexes within the whole megabasin cross section are distinguished; Oligocene and Quaternary, Turonian-Paleogene, Aptian-Albian-Cenomanian, Neocomian, Upper Jurassic, Lower-Middle Jurassic and Triassic-Paleozoic. The exploration maturity of these hydrogeological complexes is extremely variable; up to the present day the Paleozoic-Triassic hydrogeological complex is characterized only by fragmentary information obtained from single deep and ulterdeep wells.

Further oil and gas well exploration reveal new and new data on the composition and structure of deep horizons in sedimentary mantle and foundation of the West Siberian geosynecline basement. Drilling and well testing, as well as 2D- and 3D-geophysical studies are aimed to obtain information about oil and gas reservoir content and their hydrocarbon potential. This data interpretation makes it possible to identify aquiferous properties, formation conditions of underground waters and their composition, regional prediction of oil and gas occurrence, including Pre-Jurassic WSMB basement.

Tomsk scientists have made a significant contribution in the common concept of hydrogeology and petroleum hydrogeology of WSMB. For example, S.L. Shvartsev, his colleagues and students have implemented new and new ideas into the concept. S.L. Shvartsev equilibrium-non-equilibrium concept "water-rock-gas-organic-substance" system is like "a fresh grasp of air" in the existing concept of fresh groundwater formation in the hypergenesis zone as well as catagenetic processes in the deep crust horizons.

S.L. Shvartsev innovative idea of the formation of granite layer in the continental crust highlights the fact that crystallization of minerals in granitoids is a global evolutionary transformation, process of basalt which could not develop without water, controlling the equilibrium-non-equilibrium state of the thermodynamic multicomponent system "water-rock". The main factor of this system evolution is associated with the continuous dissolution of aluminosilicate calcium, magnesium, iron and formation of alumino silicate sodium, potassium, quartz within filtrated waters. "The main rock transformation process is influenced by water from the continents to form granite". In the deep water oceanic conditions the interaction of water with rocks results in rock serpentinization, and according to S.L. Shvartsev, this can explain the fact the oceanic floor is composed of not granite but of basalt.

This fact can also prove the origin of igneous rock vugs in the Pre-Jurassic WSMB basal complex and, consequently, being filled with fluids and further formation underground water horizons and oil deposits.

The groundwater technogenesis ideas of E.V. Pinneker, B.I. Pisarsky, Yu.P. Gattenberger, A.A. Kartsev became the basis for their testing and development under the conditions of Western Siberia, being the largest worldwide oil and gas complex. WSMB technogenic aspects attract Russian scientists. Our research in this field is the subject of discussion at scientific conferences and in papers from the 90-s to the present day. Some issues are directly related to petroleum hydrogeology. In 1997, the classification of WSMB technogenetic hydrogeological systems was presented and from this moment on the issues concerning reservoir and injection water into actions, their impact on rock reservoir properties, their colmation are still being investigated. Technogenic field as a factor in the formation of the geological environment, geological environment classification of oil and gas deposits, technogenesis zoning are reflected in recent scientific works (2010-2015). The latest works present the

concept of the stage development of natural and technogenic hydrogeological systems, applicable to all types of systems, including oil and gas fields [7].

5. Conclusion

Oil-field development, underground water intake exploitation for maintaining reservoir pressure (MRP), subsurface disposal of waste and associated water excess in the oil fields, provision of production field industries and the population with high quality drinking water necessitate the investigation and theoretical justification of technogenic geological environment transformation and their impact on the environmental conditions of oil and gas regions.

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