Basin Modeling in the Regions with Complex Structural and Tectonic Features

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ABSTRACT

This article covers regions with complex geological structure, distinguished by a complex history of geodynamical development having resulted in the multilayer tectonic structure of the sedimentary cover shaped in sedimentary basins after their long and complex multistage evolution. Such regions, which have passed a great number of lithosphere evolution stages, contain a large stock of hydrocarbons (HC). The authors studied petroleum systems (PS) of such regions – Western and Eastern Siberia, Pre-Ural fore-deep, the Crimean peninsula, and the water areas of the Sea of Okhotsk, the Caspian Sea, the Black Sea and the Sea of Azov.

Development and spreading of regions having a complex structure have been conditioned by non-coincidence in the tectonic geometry of structure formation layers of different ages, manifestations of regional tectonic movements changeable by vector and sign, step-block structures with high-amplitude regional deep faults, unbalanced avalanche sedimentation, intense manifestation of stress paleo- and neotectonic mechanisms – powerful disjunctive, diapir, fractural, and thrust tectonics, with active magmatic processes and mud volcanicity, high micro- and macroseismicity, earthquakes, abnormally high formation pressure, halokinesis, erosion processes, etc. in some regions.

Exploration of deep-seated resources requires the solution of a number of problems connected with studying mass exchange processes and hydrocarbon systems in the sedimentary stratum with unsteady hydrodynamics and the lower limit of HC accumulation distribution in sedimentary basins. Pilots studies and the latest deep seated oil deposit discoveries have given rise to the idea that in supercritical conditions (under abnormally high pressure) oil can be transferred into the so-called vapor-gas-oil or “oil condensate” phase, as stable as the gas condensate phase, which is proved by hydrocarbon system modeling in the Pre-Ural fore-deep and in the Caspian Trench. Not only gas, but oil deposit presence may be forecasted at great depths, though in the reservoir conditions HCs will be not in the liquid, but in the gaseous (“oil condensate”) phase.

The authors have taken the fluid dynamics of rapidly submerging basins and the existence of excitation foci in their sedimentary stratum as the basis for improvement of deep seated hydrocarbon assessment and forecasting methods. At this stage the fluid dynamic aspect of the problem is development of the methods of mapping the foci of “excitation”, or deep fluid generation foci (source rocks), channels, scales and time of hydrocarbon migration. Research results were integrated into 3D models of deep HC systems with the allowance for geodynamics and geofluid dynamics of the regions under consideration.

Halokinesis conditioned by specific properties of salt strata and uneven pressure of overlying rocks above them, differential movement of subsalt bed and foundation as a result of tectonic movements is a specific form of folded dislocations of the sedimentary layer of the crust and

foundation widespread in regions with complex structure. Such saliferous rock properties hinder basin modeling in a way. The solution to the problem is demonstrated by the example of the Pre-Ural fore deep. As a result of recalculation of the salt volume using 2D and 3D modeling methods, the thickness of the salt stratum (2 km) was revealed. Up to the end of the Early Triassic salt-bearing section was deposited according to the surrounding sediments and had about 2 km thickness. By the end of the Early Triassic the last mounting building stage initiated and powered a mighty halokinesis of the Pre-Ural fore deep and the adjacent areas of the southeast slope of the Volga-Ural anticline and the Pre-Caspian syncline. In today's salt complex structure the evaporite thickness varies from 50 m in inter-dome troughs to 5 km within some domes.