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New hydrologic model of fluid migration in deep porous media

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New hydrologic model of fluid migration in deep porous media

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The authors present a new hydrological model of mantle processes that effect on formation of oil-and-gas bearing basins, fault tectonics and thermal convection.
Any fluid migration is initially induced by lateral stresses in the crust and lithosphere which result from global geodynamic processes related to the mantle convection. The global processes are further transformed into regional movements in weakness zones.
Model of porous media in deep fractured zones and idea of self-oscillation processes in mantle layers and fractured zones of the crust at different depths was used as the basis for developed concept. The content of these notions resides in the fact that there are conditions of dynamic balance in mantle layers originating as a result of combination and alternate actions of compaction and dilatance mechanisms. These mechanisms can be manifested in different combinations and under different conditions as well as can be complemented by other processes influencing on regime of fluid migration. They can act under condition of passive margin, ocean rift and ocean subduction zones as well as in consolidated platform and sheet. Self-oscillation regime, sub vertical direction of fluid flows, anomalously high layer pressure, and high level of anomalies of various geophysical fields are common for them.
A certain class of fluid dynamic models describing consolidation of sedimentary basins, free oscillation processes slow and quick (at the final stage) fluid dynamic processes of the evolution of a sedimentary basin in subduction zones is considered for the first time. The last model of quick fluid dynamic processes reflects the process of formation of hydrocarbon deposits in the zones of collision of lithosphere plates. The results of numerical simulation and diagrams reflecting consecutive stages of the gas–fluid dynamic front propagation are assessed of the Pri-Caspian depression as the example. Calculations with this model will simultaneously be carried out for the sedimentary basins of Timan–Pechora region, Barents Sea, Volga–Ural area, etc.
Hydrologic model of deep porous media and the idea of self-oscillation processes in fractured layers of the crust at different depths were used as the basis for developed concept. The content of these notions resides in the fact that there are conditions of dynamic balance in fractured layers originating as a result of combination and alternate actions of compaction and dilatance mechanisms. These mechanisms can be manifested in different combinations and under different conditions as well as can be complemented by other processes influencing on regime of fluid migration. They can act under condition of passive margin, rift and subduction zones as well as in consolidated platform and sheet. Self-oscillation regime, sub vertical direction of fluid flows, anomalously high layer pressure, and high level of anomalies of various geophysical fields are common for them. Specific manifestations of these mechanisms can vary in dependence on geological settings and geodynamic situations. In particular, periods of self-oscillations and depths of fractured layers can be various. Orientation of layers can be not only horizontal, but vertical as well, that is, self-oscillations can occur not only in deep porous media, but in faults and impaired fractured zones as well. Predominating vertical fluid migration can be accompanied by horizontal migration along

crust waveguide.

A set of fluid dynamic models is considered. Mathematical modeling of geodynamic and fluid dynamic processes in these zones seems very promising. Combined consideration of geodynamic and fluid dynamic aspects in a model of lithosphere plates collision enables to understand the influence of P–T conditions and shear deformations on the mechanism of hydrocarbon generation and to look after their migration and to explain these processes, but also to predict some features essential for the search and exploration of hydrocarbon fields in these regions and their classification.

In terms of compaction models, multiphase filtration in a piezo-conduction mode and models of deep porous media major stages of fluid evolution under the conditions of developing passive margins and in the zones of collision of plates are described. In particular, compaction models of one of the stages of fluid mode evolution within a sedimentary basin and fluid migration from the convergence zones toward the upper layers are considered.

In the final part of work, computation of fluid transfer of hydrocarbons in a pulse mode described by the equation of piezo-conductivity is presented for a mature oil-bearing sedimentary basin over individual sections for short periods of a few hundreds of years. These calculations were executed on the basis of a new mathematical method TEKON and computer programs for quantitative analysis of fluid migration and formation of hydrocarbon deposits with account taken for actual geometrical and lithological properties of the layers. On the basis of the specified numerical calculations the scales, form, and routes of fluid movement were disclosed, as well as the formation of zones of anomalously high rock pressure and non-traditional hydrocarbon deposits.