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**IDENTIFICATION OF FORMATION PERMEABILITY FIELD USING
DIFFERENT APPROXIMATION TYPES IN SINGLE-PHASE STEADY-
STATE FLOW PROBLEM**

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Abstract. A comparison of different types of the permeability field parameterization at its identification is performed. The spline function, piecewise constant and piecewise bilinear functions are used to approximate the permeability field. The identification task of the permeability field is reduced to minimization of the residual function. The advantage of using the spline function in comparison with other types of approximation is shown on the model tasks.

Key words: *permeability identification; inverse problem; approximation of permeability; minimization of residual function; method of Levenberg-Marquardt.*

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TRACER STUDIES DETERMINE SPATIAL ORIENTATION OF FRACTURES IN CARBONATE RESERVOIRS USING GEOLOGICAL AND RESERVOIR SIMULATION MODELLING

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Abstract. An available geological and reservoir simulation model for Tournaisian and Devonian sediments of the Deposit No. 101 of Novo-Elkhovskoye oil field was used to refine the geological structure of producing formations based on the results of tracer studies.

Reservoir production history matching have been performed using two different approaches. *The first approach* relies merely on production performance data for adjustment of reservoir parameters and does not consider the results of tracer studies. This approach is called traditional. Fracture network permeability in X, Y and Z directions have been adjusted at 1000 μm^2 . *The second approach* implies consideration of both production performance data and the results of tracer studies. The second approach to history matching yields a substantially different result in terms of fluid flow characteristics. Particularly, fracture permeability in X direction has been estimated at 1300 μm^2 , while fracture permeabilities in Y and Z directions are 100 μm^2 and 1000 μm^2 respectively. Predicted cumulative oil production according to traditional approach stands at 1471 thousand tons compared to 1728 thousand tons obtained using the second approach.

Key words: *Tournaisian deposits, tracer studies, fracture network, history matching, fluid flow, geological and reservoir simulation models, tracer transport rate, fluorescein injection*

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DEVELOPMENT OF CONCEPT OF RESERVES REPLACEMENT IN THE PROCESS OF OIL PRODUCTION

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Abstract. The paper discusses the earlier offered concept about the origin of hydrocarbons and replacement of reserves in depleted reservoirs. Two main issues are addressed, the possible existence of “oil delivery” channels to bring oil to the reservoir, and the effect of water injection on the rate of oil reserves replacement. However, reasoning based on the postulate of existence of “oil delivery” channels leads to occurrence of a number of contradictions that can only be resolved by introducing more postulates. Instead, we recommend using the earlier offered concept based on Nikolai Levashov’s paradigm, which, as put by Stephen Hawking, is “a unified theory of everything”. Using this concept we can consider many challenging issues related to exploration and production of oil fields using few postulates. The problem of the effect of waterflooding on oil reserves replacement has been addressed. It is shown that as recoverable reserves are depleted, the rate of synthesis comes up to the production rate, providing, thus, for a sustained oil production in the long term.

Key words: *oil synthesis, oil charge, oil delivery channel, oil production, primal matter, curvature, relaxation time.*

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**OPTIMIZING THE DEVELOPMENT OF FAULTED UPPER
DEVONIAN TERRIGENOUS SEDIMENTS OF ELABUZHSKOYE OIL
FIELD USING GEOLOGICAL AND RESERVOIR SIMULATION
MODELING**

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Abstract. Geological and fluid flow models have been created for faulted Upper Devonian terrigenous sediments of Elabuzhskoye oil field. Reservoir simulations have been run to predict oil production performance of Upper Devonian terrigenous reservoirs. Production forecasts have been made for two field development scenarios, depending on current development status of the production zone, with the aim to optimize field development system. Production decline observed over the past fifteen years necessitates drilling of new wells. Thus, the authors of the paper have used the results of reservoir simulation study to come up with a drilling strategy providing for selective placement of new wells. The drilling program implies drilling of 25 production and four injection wells, unplugging of two abandoned wells and sidetracking of two lateral holes.

Key words: *fault, terrigenous reservoir, Bashkirian stage, geological and fluid flow models, interpretation of well logging data, relative permeability, history matching, sidetrack drilling*

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ASPECTS OF HYDRAULIC FRACTURE PROPAGATION IN TATARSTAN FIELDS

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Abstract. This paper reviews publications on microseismic monitoring of hydraulic fracturing operations performed in Tatarstan fields. Results of foreign and domestic research in other regions have been compared.

The following conclusions have been made:

1. Horizontal stress field at a depth of 1400-1700 m is almost isotropic.
2. Under such conditions, the induced fractures tend to propagate along the direction of natural fractures, thus generating a fractured zone.
3. Expansion of the fractured zone continues after the injection stops.
4. It is necessary to perform microseismic monitoring for proving complex stratification and critical stress parameters.

Key words: *microseismic activity, fractured zone, horizontal stress, discrete well pattern, hydraulic fracturing, well testing*

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**RESERVOIR SIMULATION STUDY FOR ESTIMATING THE
DENSITY OF MOBILE OIL RESERVES AND FORECASTING
RESERVOIR PRODUCTION PERFORMANCE FOR CARBONATE
SEDIMENTS OF THE KIZELOVIAN PRODUCING INTERVAL OF
ZAPADNO-URUSTAMAKSKOYE OIL FIELD**

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Abstract. Initial oil saturations have been obtained from Leverett J-function versus water saturation for Kizelovian sediments. History matching and forecasting data are indicative of the degree of match between predicted and actual field production data.

Geological and fluid flow models have been created for carbonate sediments of the Kizelovian producing interval considering Leverett J-function versus water saturation.

Historical production data for the Kizelovian production zone have been used to history match model parameters. Reservoir simulations were run to predict reservoir production performance after drilling of four horizontal sidetracks. Cumulative oil production by the end of field development period has been estimated at 99 000 tones with oil recovery factor of 0.270.

Key words: *geological and reservoir simulation model, residual oil saturation, pay zone, Kizelovian horizon, formation, structural framework, geological cross section, oil-water contact, history matching, critical water cut, mobile oil reserves.*

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**EVALUATING OIL PRODUCTION PERFORMANCE OF
BASHKIRIAN-STAGE CARBONATE RESERVOIRS OF
KAMYSHLINSKOYE OIL FIELD BASED ON GEOLOGICAL AND
FLUID FLOW MODEL**

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Abstract. The paper looks at such issues as the construction of a geological and reservoir simulation model for carbonate reservoirs of Kamyshlinskoye oil field, history matching of the resultant model to actual field production data, and application of the results and history matching parameters for prediction of production performance of producing reservoirs. Geological and fluid flow model has been created for carbonate sediments of the Bashkirian stage considering Leverett J-function versus water saturation. History matching of the model has been performed based on historical production data of the Kizelovian producing interval. Reservoir simulation runs have encompassed various improved and enhanced recovery methods.

Key words: *reservoir, formation, Bashkirian stage, geological fluid flow model, middle Carboniferous, interpretation of well logging data, crossplot, relative permeability, production history, mobile oil*

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GEOTHERMAL ENERGY AS EFFICIENT MEANS OF ENERGY SAVING IN RUSSIAN OIL FIELDS

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Abstract. Over the period of oil field development in Russia, more than one and a half million wells have been drilled and put on stream, including exploratory, stratigraphic, and production wells. The majority of these wells (over 30%) became exhausted and were suspended or abandoned. These wells could be used for utilization of geothermal energy of penetrated formations; however, this is not put into practice. Studies and experience of other countries prove high potential of this method in power generation and house heating in cold season. This paper presents reasons for extensive use of this technology with the view of energy saving, especially in mature fields.

Key words: *geothermal energy, energy saving, environment, utilization, geothermal station, electrical and thermal energy, skid-mounted geothermal station*

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POTENTIAL OF CONVERTING LOW-TEMPERATURE GEOTHERMAL ENERGY TO ELECTRIC ENERGY

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Abstract. The paper discusses possibility of converting low-temperature geothermal energy (max 45-50°C) to electric energy. This problem attracts interest since there are a lot of wells (over 300,000) with depth up to 2000 m in the Volga-Ural region drilled to produce unconventional oil, which requires unreasonably high energy consumption. Modern innovative fuel cells can be a source of relatively cheap energy, as well as generate sufficient amount of thermal energy to heat producing formations and wellbore fluids that are lifted to the surface. Application of these fuel cells opens far-reaching possibilities for significant energy savings for marginal wells when producing unconventional reserves from relatively shallow reservoirs (less than 2000 m) with low-temperature geothermal energy.

Key words: *geothermal energy, fuel cells, unconventional reserves, ESP, separator, binary heat-exchange loop, compressor, heat exchanger, condenser, electric steam generator*

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**ON WAYS OF PETROTHERMAL ENERGY UTILIZATION IN
OIL PRODUCING REGIONS WITH LOW GEOTHERMAL
POTENTIAL OF FORMATIONS**

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Abstract. This paper discusses possibilities for energy saving during oil field development in regions with low geothermal potential of producing formations where rock temperature gradient is maximum 2-2.5°/100 m. These regions include Bashkortostan, Tatarstan, Udmurtia, and others. An integrated approach to solving this problem involves utilization of low-temperature geothermal energy of the produced fluids using thermoelectric elements along with utilization of hydrokinetic energy of the injected water using hydroelectric turbines.

Key words: *petrothermal energy, rock temperature gradient, hydrokinetic energy, thermoelectric elements, hydroelectric turbine*