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FROM RESOURCE-BASED TO INNOVATION-DRIVEN GROWTH OF RUSSIAN OIL INDUSTRY: CHALLENGES AND PROSPECTS

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Abstract. Conventional oil-and-gas reservoir performance is greatly affected by significant Western technological advances in evaluation and production of unconventional hydrocarbon reserves. Potential has emerged for transition from commercial reserves to original-hydrocarbon-in-place estimation, as well as change from absolute to effective pore volume concept in the area of reserves estimation and reservoir engineering. This paper demonstrates the need for an innovative approach to all stages of hydrocarbon reservoir analysis and development, including rock and fluid lab analysis up to the nanoscale level, rock physics, well logging, new approach to reservoir simulation, selection of new production techniques based on the laboratory and mathematical simulations, field trials, and innovation-driven engineering.

Key words: *tight rock, shales, unconventional oil, unconventional oil reservoirs, heavy oil, natural bitumen, oil recovery factor, enhanced oil recovery, well stimulation, hydrofracturing, laboratory analysis, well logging, geologic and reservoir simulation models, innovation-based engineering, mature fields.*

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**GEOLOGICAL AND PHYSICAL ASPECTS OF CYCLIC
WATERFLOOD APPLICATIONS IN CARBONATE RESERVOIRS AT
LATE STAGES OF THEIR DEVELOPMENT**

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Abstract. The paper considers special aspects of the development of fracture network in carbonate reservoirs. It has been demonstrated that natural fractures are confined to local variations of geological conditions of their occurrence. As has been determined, fractures' orientation and opening depend largely on bedding angles and deposition of mineral and organogenous sediments. It is proved that due to these geological and physical peculiarities water permeability and fracture porosity of carbonate reservoirs are less dependent on the relation between reservoir and rock pressures as compared to terrigenous reservoirs, thus favouring application of cyclic waterflooding in carbonate reservoirs. This conclusion has been field proven at the Znamenskoye oil field in the Republic of Bashkortostan.

Key words: *fracture porosity, angle of bedding, fracture opening, mineral and inorganic sediments, cyclic waterflooding, productivity.*

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**CHARACTERISTICS OF MODIFIED LIGNOSULPHONATES
ADSORPTION ON SOLID PHASES**

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Abstract. The paper considers the issues of adsorption activity of lignosulfonates obtained by neutral sulfite delignification and modified lignosulfonates. For modification of neutral sulfite lignosulfonates, multivalent cations and phosphonic groups were used. Surface tension of various-concentration lignosulfonates solutions at the fluid-fluid boundary was measured, then, adsorption on solid phases was determined. Bentonite (clay) and quartz sand were used as solid phases. It was found that modification by multivalent cations results in quantitative increase of adsorption activity of neutral sulfite lignosulfonates, however, the adsorption curves for bentonite and quartz sand differ, just as the value of adsorption measured in grams per unit mass of adsorbent. Additional modification of ferro-chromelignosulfonate by phosphonic groups significantly increases adsorption activity of lignosulfonates.

Keywords: *sulphite waste lye, lignosulfonate, modifiers, adsorption, adsorption isotherms, solid phases.*

УДК 622.276.42

**EVALUATION OF OIL RECOVERY EFFICIENCY FOR WAG
PROCESS IN VARIOUS DEVELOPMENT SCENARIOS**

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Abstract. Water-alternating-gas injection (WAG) is one of the ways to improve reservoir performance. This paper reviews the applicability of this technique in a Tournaisian pilot area, the Romashkinskoye oil field. Reservoir simulation models are used to study the effect of the nitrogen-based WAG process on sweep efficiency. The simulation models use conventional seven-spot well patterns with varying spacing.

Key words: *gas injection, nitrogen injection, water-alternating-gas injection, improved oil recovery*

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**ACID TREATMENT OF BOTTOMHOLE ZONE AT RESERVOIR
PRESSURES BELOW BUBBLE POINT**

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Abstract. The paper presents the technology for acid treatment of the bottomhole zone using acid-forming water-repellent emulsion. The technology is intended for use in carbonate reservoirs with a complex pore structure and reservoir pressures 10-15% below bubble-point pressure.

Before this technology was put forth considerable work had been done in the laboratory to demonstrate applicability of the proposed method. The paper provides the results of the research efforts. Implementation of the technology in nine production wells in the Orenburg Region increased oil production rates by 50%, on the average.

Key words: *acid treatment, bubble-point pressure, adsorption oil, acid-forming emulsion, emulsion breakdown time, relative permeability, efficiency.*

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CALIBRATION TEST EFFICIENCY IN SHALE FORMATIONS

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Abstract. In 2013-2015, PJSC TATNEFT implemented pilot projects on hydrofracturing of Mendym, Domanic, and Sargaev formations, covering 14 wells of different NGDUs. The success rate of frac jobs in Domanic reservoirs was as low as 33%.

Even though frac jobs were carried out in extra-low-permeability reservoirs, a conventional fracturing technique was used based on crosslinked gel injection. Almost all frac jobs involved multi-zone fracturing, including calibration tests.

Pilot project results have revealed insufficiency of producing formation data for successful hydraulic fracturing treatments. Full range of well logging operations is recommended for a stimulated interval while designing fracture treatments. In addition, shale fracturing techniques should be used which are applied worldwide and which have proved to be efficient, such as use of linear gel fracturing fluids or a hybrid fracturing technique.

Key words: *calibration test, Domanic formations, fracture closure point, controlled flow back*

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**STUDY OF FLOCCULATION AND SEDIMENTATION
OF ASPHALTENES IN HEAVY OIL BY UV-SPECTROPHOTOMETRIC
KINEMATIC ANALYSIS**

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Abstract. To study the processes of asphaltenes flocculation and sedimentation in toluene solution on addition of *n*-heptane above flocculation start point, an UV-spectrophotometer with automatic optical density over time registration was used. It has been found that optical density increases once flocculation has started and decreases after sedimentation of asphaltenes. By example of asphaltenes of heavy oils from the Ashalchinskoe and Mordovo-Karmalskoye oil fields it has been shown that these processes are consistent with characteristics of structural-group composition. Also, the potency of spectrophotometric method to evaluate asphaltenes behavior while flocculation and sedimentation in presence of a synthetic amphiphile–nonylphenol has been demonstrated.

Key words: *heavy oil, asphaltenes, flocculation, precipitation, optical density.*

УДК 622.276.72

**PROBLEMS OF REMOVAL ASPHALTENE PARAFFIN SEDIMENTS
AT UDMURTIA AND TATARSTAN OILFIELDS ON MODERN STAGE**

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Abstract. In this article we consider the existing methods of dealing with asphaltene sediments. Based on the experience gained on the fields of Udmurtia and Tatarstan, it was concluded that the high efficiency of the thermal method, which should be optimized in terms of energy consumption.

Key words: *Asphaltene sediments, the viscosity of the oil, the thermal method, the energy efficiency, oil recovery.*

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**COMPOSITION AND PROPERTIES OF ASPHALTENES FROM
DEVONIAN AND CARBONIFEROUS OILS ON THE EXAMPLE OF
TATARSTAN OILFIELDS**

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Abstract. The difference between petroleum asphaltenes from Devonian and Carboniferous reservoirs of Tatarstan was shown. Asphaltenes derived from Devonian oils can be characterized as a concentrate of polycondensed aromatic hydrocarbons with relatively low content of heteroatomic components and metallocomplexes. On the contrary, asphaltenes derived from Carboniferous oils are characterized by the lower content of polycondensed aromatic hydrocarbons and the higher amount of heteroatomic components and metallocomplexes. Correlation between optical density (light absorption coefficient) and paramagnetism of petroleum asphaltenes was revealed. Light absorption characteristics of asphaltenes can be applied in solving practical problems concerning the differentiation of the oils from the various productive reservoirs.

Key words: *petroleum asphaltenes, light absorption coefficient, paramagnetism.*

**RELEVANCE OF CONSOLIDATING SCIENTIFIC ENGINEERING
POTENTIAL OF THE VOLGA-KAMA DIVISION OF RANS -
“IT’S TIME TO GATHER STONES”**

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Abstract. This paper presents information from the Russian Energy Security Program by 2030, with a particular focus on failure to comply with its objectives over the Volga Federal District. The authors point out that oil recovery factor is not very high, being less than in foreign oil companies. They also give some data on low efficiency of unconventional-reserves production techniques and rise in cost of services provided by oilfield service companies, which greatly affects oil lifting costs. One of the reasons for low efficiency of unconventional-reserves development is lack of systematic approach to this problem, both from research and service companies. To support this idea, the authors refer to scientific papers and thesis projects by TATNEFT’s and TatNIPIneft’s employees, published in 2016. All these papers address current problems relating to mature oilfield development.

Key words: *oil recovery factor, unconventional reserves, oil lifting cost, services, well logging, hydraulic fracturing, dual completion, smart wells*