Integrated Geochemical Sudies to Monitor Processes in a Mature Oil Field after Peak Oil Production

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The majority of large oil field worldwide is known to produce oil at rates below the peak production. A better understanding of the processes in an oil deposit related due to a particular technology of oil production and the duration of its application is needed by conducting laboratory studies. Both organic and inorganic chemical studies are a powerful tool for such studies.

Alterations in the reservoir rock properties and mobility of reservoir fluids are to be taken into account when decisions are made regarding a strategy of the development of an oil field and reservoir management. An integrated investigation of the core material and reservoir fluids from the D1 oil deposit in the Romashkino oil field, Tatarstan, Russia, has been conducted. The results show that the non-uniformity of the oil deposit is related to both different mineralogy of the cement in the reservoir rock (smectite, kaolinite, dolomite, pyrite, etc.) and the alterations in the oil composition caused by a long-term waterflooding. Such phenomena have different effects at the formation of the residual oil in different areas of the oil field. The study shows that two factors make reservoir rock oil wet: (1) irreversible adsorption of oil components on clay minerals and (2) insoluble residue of carbene-carboid compounds as products of asphaltene transformations. Asphaltenes in the immobile layer of oil (oil adsorbed on the reservoir rock) are the indicators of the processes taking place at the oil-water-rock interface.

A database of experimental data for approximately 150 oil samples from the D1 oil deposit has been created to determine the major physical and chemical processes causing transformations in the mobile (produced) oil. Physical and chemical characteristics of oil together with hydrocarbon, fraction, structural-group and component compositions were determined. Asphaltene composition was investigated by thermal analysis and EPR spectroscopy. Statistical analysis was done taking into account the field data related to the oil well performance at the moment when oil was sampled. The analysis shows the most important factors affecting the alterations in oil composition and properties for each oil well.

As a result of the integrated geochemical studies, an original technique has been developed to differentiate oil in a mature oil field after the peak oil production. Alterations in the oil composition are discussed in regards to production of residual oil, paraffin crystallization, concentration of tar-asphaltene compounds in the reservoir, asphaltene deposition and improved sweep efficiency in low-permeability zones. The technique can be used to evaluate efficiency of the different enhanced oil recovery technologies.