Geophysical Research Abstracts
Vol. 16, EGU2014-14735, 2014
EGU General Assembly 2014

Petrophysical, Lithological and Mineralogical Characteristics of the Shale Strata of the Volga- Ural Region

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The objects of the study are Upper Devonian carbonate rocks in the territory of South-Tatar arch and Melekess basin in the Volga- Urals region. We studied core material of Domanicoid facies from the sediments of Mendymski and Domanik horizons of middle substage of Frasnian stage of the Upper Devonian.
Basic analytical research methods included the following: study of the composition, structural and textural features of the rocks, the structure of their voids, filter and reservoir properties and composition of the fluid. The complex research consisted of macroscopic description of the core material, optical microscopy analysis, radiographical analysis, thermal analysis, x-ray tomography, electron microscopy, gas-liquid chromatography, chromate-mass spectrometry, light hydrocarbons analysis using paraphase assay, adsorbed gases analysis, and thermal vacuum degassing method. In addition, we performed isotopic studies of hydrocarbons saturating shale rocks.
Shale strata are mainly represented by carbonate-chert rocks. They consist mainly of calcite and quartz. The ratio of these rock-forming minerals varies widely - from 25 to 75 percent. Pyrite, muscovite, albite, and microcline are the most common inclusions. Calcareous and ferruginous dolomite (ankerite), as well as magnesian calcite are tracked down as secondary minerals.
While performing the tests we found out that the walls of open fractures filled with oil are stacked by secondary dolomite, which should be considered as an indication moveable oil presence in the open-cut.
Electron microscopy data indicate that all the studied samples have porosity – both carbonates and carbonate-siliceous rocks. Idiomorphism of the rock-forming grains and pores that are visible under a microscope bring us to that conclusion. The analysis of the images indicates that the type of reservoir is either porous or granular. The pores are distributed evenly in the volume of rock. Their size is very unstable and varies from 0.5 microns to 100 microns. The lowest value are observed in long carbonate-siliceous rocks, the highest values are found in carbonate rocks. The latter is caused by the fact that there is a very strong recrystallization of calcite and its dolomite substitution in carbonates.
Open porosity ranges from 0.65 to 7.98 percent, average value is 4.1percent . Effective porosity has an average value of 0.44 percent, ranging from 0.22 to 1.97. Permeability varies from 0.043 to 1.49 mD, average value is 0,191 mD.
Organic matter was found in all samples. Its content varies within the section. The fluctuation range of from 1.0 to 20 percent. The lowest content of carbonates is found in carbonates, while the highest is observed in carbonate-siliceous rocks with a high content of chalcedony. Average organic matter content is 5-7 percent. According to Rock-Eval studies of the core, the catagenetic maturity of organic matter corresponds to MK1 - MK2 degree.
We found a connection between the type of organic matter and the composition of adsorbed gas. We also could see that the samples with humic organics present in their organic matter and can be characterized by a fair dominance of methane over other gases. There is a clear relationship between organic matter content and the intensity of the gas saturation of the rock.
Organic matter is characteristic mainly of the most siliceous formations. In "pure" carbonates, which are represented by micro-layers with different capacities, OM is not observed at all or its content is quite low.