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Advances in coalbed methane reservoirs integrated characterization and hydraulic fracturing for improved gas recovery in Karaganda Coal Basin, Kazakhstan

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Abstract

Coalbed methane (CBM) fields in Karaganda Coal Basin are characterized by geological and structural complexity. Majority of production zones have high methane content and extremely low permeability of the coal seams that lead to reservoir stimulation problems. In order to have a successful hydraulic fracturing program we applied integrated reservoir characterization to monitor key parameters. In addition to logging data, core sample analysis was applied to observe the relation between lithological variations found by the use of magnetic susceptibility values and permeability measurements to identify the best CBM reservoir candidates for hydraulic fracturing.

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Keywords: Unconventional reservoir; coal; coalbed methane; Karaganda Coal Basin; hydraulic fracturing; magnetic susceptibility; permeability

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1. Introduction

Coalbed methane from Karaganda coal basin is considered to be an unconventional source of energy for the Central and Eastern parts of Kazakhstan. These regions are situated far away from the main traditional sources of oil and gas related to Precaspian petroleum basin. Coalbed methane fields in Karaganda Coal Basin are characterized by geological and structural complexity. Majority of production zones have high methane content and extremely low coal permeability, which might lead to production problems in gas recovery.

CBM reservoir stimulation choices are influenced by reservoir characteristics. Coal reservoir is not continuously uniform in composition, which influences heterogeneity of total organic content distribution, cleat development and permeability. In order to understand this complexity we applied integrated reservoir characterization using probe permeability measurements of unstressed core collected from the wells, magnetic susceptibility measurements, maceral analysis and desorption studies. We also estimated potential influence of these parameters on successful hydraulic fracturing.

2. Geological background

Republic of Kazakhstan has enormous resources of coalbed methane, which are estimated to be 2-8 trillion m^3, with the main Basins: Karaganda, which has 2-4.3 trillion m^3 of coalbed methane, Ekibastuzsky with 70 billion m^3, Tengiz-Korzhunkolsky with 45 billion m^3 and Samarskoe and Zavyalovskoe deposits.

Karaganda Coal Basin is an asymmetrical, large, complicated syncline of a bi-systemic type, which is elongated in the latitudinal direction. It is characterized by high gas content. The geological structure of the Karaganda Basin is represented by formations of Paleozoic, Mesozoic and Cenozoic periods. Coal-bearing units of the Karaganda Coal Basin are related to Carboniferous and Jurassic deposits. Carboniferous coal-bearing deposits include Ashlyarikskaya, Karagandinskaya, Dolinskaya and Tentekskaya coal-bearing formations. Tectonically the Karaganda Basin is a part of Karaganda Synclinorium of a latitudinal distribution and located in the middle part of it. The Basin is limited by the Zhalairskyi Thrust in the South, Devonian sedimentary and volcanic rocks in the North, the large Tentekskaya Fault with a displacement amplitude of 4 - 5 km in the West, area of the carbon development is narrowed in the East Alabayskaya I Anticline and Maykudukskoe Lifting are dividing the Basin into three major troughs: Tchurubay-Nurynskaya, Karagandinskaya and Verhnesokurskaya (from the West to the East) [1, 2, 3, 4].

3. Methodology

All substances, solids and fluids response when magnetic field is applied. Magnetic susceptibility is an extensively applied characteristic of a rock that describes the amount of ferromagnetic components in the formation, majorly magnetite. Recent studies presented possible applications of magnetic susceptibility for reservoir evaluation, quantifying petroleum fluids and minerals, and for prediction of important petrophysical parameters in clastic reservoirs [5, 6, 7, 8].

In this study, we carried out probe measurements of magnetic susceptibility and permeability profiles for different CBM reservoir intervals and micro-profiling of large coal samples from the coal-bearing Basin in Karaganda, Kazakhstan. Magnetic susceptibility and permeability were measured at same depth points allowing correlation with a vertical resolution of 3-5 cm, depending on rock structure. Portable handheld air permeameter probe value is given as soon as the measurement is done. Magnetic susceptibility tool measures volume magnetic susceptibility of the rock in SI units and can operate in magnetic susceptibility variations up to 26 SI units with a measurement time as minimum as 0.1 s. These measurements were carried out and analyzed with respect to other core analysis results. The experimental results of magnetic susceptibility and permeability of formations were compared with each other in order to confirm the existence of the correspondence between magnetic susceptibility and permeability, when low MS corresponds with high permeability and vice versa. Graphs that were plotted according to the obtained results display relationships of magnetic susceptibility and permeability helped to characterize the coal samples precisely [9]. The relation between the potential production rate and type of the fractured coal interval was estimated based on the permeability variation in the coal sections.