Coalbed Methane Production Potential for Taldykuduk Block Karaganda Coal Basin, Kazakhstan

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Keywords : Coalbed methane, dual porosity, CO_2

1 Introduction

Methane production from coal seams has acquired special relevance in the last years. Last century the degassing of coal mines was carried out to ensure the mine safety technology for coal extraction. Now the exploitation of coal deposits is directed for methane production. The Central and Eastern parts of Kazakhstan are distanced from the major resources of oil and gas, which are situated in Pre-Caspian region. Coal bed methane (CBM) from Karaganda coal basin is considered as an alternative source of energy for these regions. The history of coal production from Karaganda basin allowed to accumulate a large amount of data about gas contents in the local blocks and the coal properties. One of the best candidates to develop CBM production is Taldykuduk coal block, Fig.1, where the reserves of methane are estimated about 23.5 BNm3 with gas content in coal about 17-29 Nm^3/t, Fig.2. The objective of this work is to model the real case of Taldykuduk coal block and study the major factors, influenced on production technology. Actually the methane produced during the coal mining in Karaganda is released into the atmosphere; its collecting will reduce the climate warming effect and satisfy the local industry needs in energy.

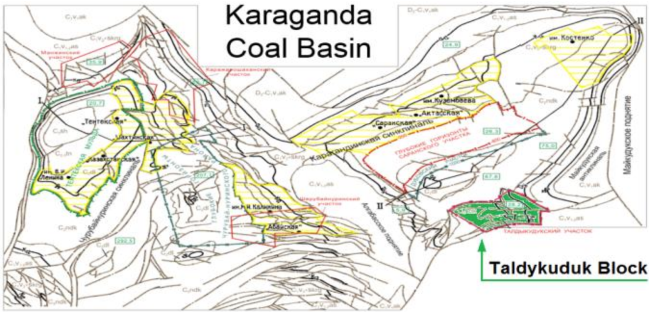

Figure 1: Favorable candidate for CBM production.

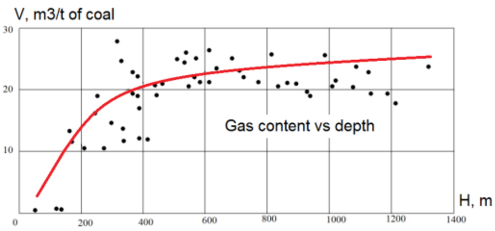

Figure 2: Gas content measurements vs depth, Taldykuduk block

2 Model formulation

The dual porosity approach is commonly used to model the methane production from coal seams [1]. At initial stage the fractures (cleats) are saturated by water and a huge amount of gas is adsorbed in the coal matrix. The technology of methane extraction is based on the primary production of a big volume of water (dewatering) to reduce the reservoir pressure. Then the gas can be desorbed and diffuses to the coal cleats. Water and gas two-phase flow in the cleats is driven by the condition at the production well. The mass conservation equations for fractures and matrix have the following form:

$$\frac{\partial(\phi_f \rho_w S_w)}{\partial t} - \nabla.\left(\rho_w \frac{K_f k_{rw}}{\mu_w} \nabla P_w\right) = 0, \quad \frac{\partial(\phi_f \rho_g S_g)}{\partial t} - \nabla\left(\rho_g \frac{K_f k_{rg}}{\mu_g} \nabla P_g\right) = \alpha M_g (C_m - C_f),$$

$$\frac{\partial n_m}{\partial t} - \nabla(\phi_m D_m \nabla C_m) = \alpha(C_f - C_m), \qquad \text{where } n_m = \rho_{ga}\rho_c V/M_g, \quad \alpha = \sigma\phi_m D_m,$$

ϕ is the porosity, K the cleats absolute permeability, ρ_i the density of i-phase, S_i the i-phase saturation, k_{ri} the i-phase relative permeability for gas and water respectively, n_m is mole amount of adsorbed gas in coal matrix, M_g is molar mass of methane. The gas transport from matrix to cleats depends on the gas exchange coefficient α, which is proportional to the specific area of exchange between matrix (*m*) and fractures (*f*) σ, the porosity ϕ_m and the gas diffusion coefficient D_m. Molar concentrations of gas, C_m and C_f, are determined according to the gas state equation and depend on pressures, P_m. and P_f respectively. The model considers the gas desorption in the matrix using the Langmuir isotherm: $V = V_L P_m / (P_L + P_m)$, where V is the gas volume, contained in 1 kg of coal; the Langmuir pressure P_L (1.8 MPa) and the volume constant V_L (0.029 m^3/kg) are estimated from a Taldykuduk block [3]. The capillary pressure in cleats, $P_c = P_g - P_l$, is taken in consideration. Fig.3 shows the initial and limit conditions on one element of the drainage area.

3 Results and discussion

Fig.4 shows the gas pressure in cleats after 1 month of production for the anisotropic case of cleat permeability: K_x=10 mD, K_y= 100 mD and gas diffusion $D_m = 10^{-10}$ m^2/s. The pressure difference $P_m - P_f$ is significant during the dewatering stage for the first two months of production, as shown on Fig.5.

The gas production rate (Fig.5) has its maximum at the moment when the water in cleats is no more the constraint for the gas flow, caused by the diffusive flux from matrix. So, the maximum of production depends on the competition between the diffusion from matrix and the resistance for transport in fractures.

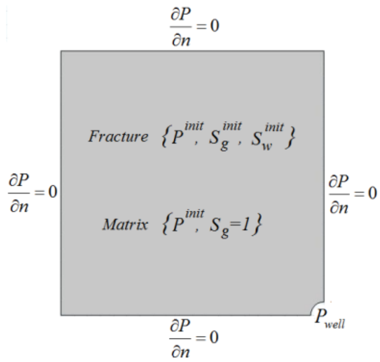

Figure 3: One element of model pattern.

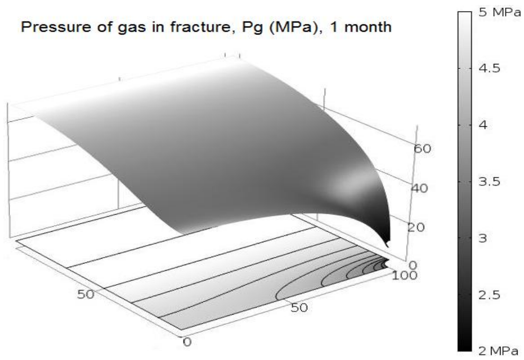

Figure 4: Variation of fracture gas pressure vs time.

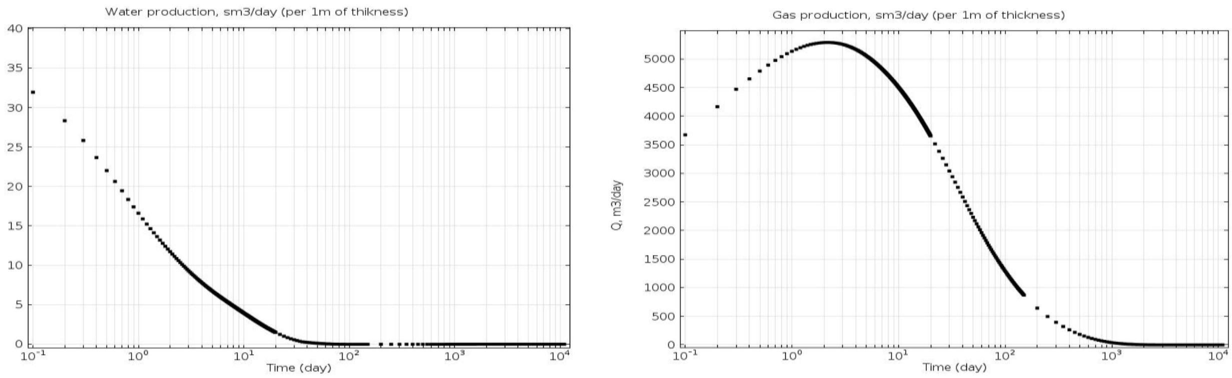

Figure 5: Water and gas production per 1m of coal layer thickness from a drainage element of 200m x 200m.

The methane desorption by CO_2 injection is also examined and it proves the higher production of CBM in comparison with the natural depletion because of the high sorption capacity of coals for CO_2.

References

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