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Modelling of gas recovery from South African shale reservoirs (focusing on the KWV-1 bore hole in the Eastern Cape Province)

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Abstract

The main aim of the study was to develop mathematical flow model of the shale gas at the Karoo Basin of South Africa (SA). The model development incorporates three systems (phases) to form a triple continuum flow model, the phases include matrix (m), natural (NF) and hydraulic fracture (HF).

The model was developed from the continuity equation, and the general equations were formed.

$$(0.05\frac{\partial p_m}{\partial t} = 3.90087 \times 10^{-15}\frac{\partial^2 p_m}{\partial x^2} + 3.90087 \times 10^{-15}\frac{\partial^2 p_m}{\partial x^2} - 1.95043 \times 10^{-16}(20 \times 10^6 - p_{NF}),$$

$$0.01\frac{\partial p_{NF}}{\partial t} = 2.00 \times 10^{-15}(20 \times 10^6 - p_{NF}) - 2.00 \times 10^{-9}(20 \times 10^6 - p_{HF}) + \frac{\partial}{\partial x}\left[7.80 \times 10^{-5}\frac{\partial p_{NF}}{\partial x}\right] + \frac{\partial}{\partial y}\left[7.80 \times 10^{-5}\frac{\partial p_{NF}}{\partial y}\right]$$

$$\frac{\partial}{\partial y}\left[0.1248269\frac{\partial p_{HF}}{\partial y}\right] + 0.1248269(20 \times 10^6 - p_{HF}) - 4.98 \times 10^{-4} = \frac{\partial p_{HF}}{\partial t}$$

The model was solved using numerical method technique known as Finite Difference Method (FDM). For each phase a computer program MATLAB was used to plot the pressure gradient. Hydraulic pressure gradient fractures propagate between the distance of 100m and 500m. The model was verified using the data of Barnett Shale. Sensitivity analysis was also performed on the hydraulic permeability, drainage radius and the initial pressure of the reservoir.