

A NEW MULTISCALE MODEL FOR METHANE FLOW IN SHALE GAS RESERVOIRS INCLUDING ADSORPTION IN ORGANIC NANOPORES AND ON CLAY SURFACES

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Abstract

The coupling between gas flow and transport in hydraulic fractures and matrix blocks in multi-porosity shale gas reservoirs is rigorously derived within the framework of the homogenization procedure applied to upscale the Thermodynamics of inhomogeneous gases in nanopores combined with a reduced dimension technique that treats hydraulic fractures and $n-1$ interfaces ($n=2,3$). At the finest scale (nanoscale) the Density Functional Theory is applied to construct general adsorption isotherms and local density profiles of methane in the nanopores of the kerogen reproducing the monolayer surface adsorption ruled by the Langmuir rule in the asymptotic regime of large pore size distributions. By postulating a reactive transport model for gas movement in the micrometer sized pores and also incorporating surface adsorption in the vicinity of the clay content of the inorganic matter, a second rigorous upscaling with both organic and inorganic matters is performed giving rise to a new nonlinear pressure equation for gas flow in the shale matrix. The methodology allows to reconstruct the constitutive law for the new storage parameter dependent on the total carbon (TOC) and clay contents. The new pressure equation in the shale matrix is coupled with single phase gas flow in the hydraulic fractures ruled by the non-Darcy Forchheimer's flow. The reduction of dimensionality method is applied to treat fractures as interfaces by averaging the flow equation across the fracture aperture. Combination of the methods give rise to a new matrix/fracture coupled problem. Numerical simulations illustrate the potential of the multiscale approach proposed herein in quantifying the influence of methane adsorption on the clay surface along with its influence upon gas production curves.

References

[1] T. D. Le, M. A. Murad, P. A. Pereira, C. Boutin, E. L. Garcia and S. A. Lima, "A New Multi-scale Computational Model for Flow and Transport in Shale Gas Reservoirs Rigorously Derived by Reiterated

Homogenization”, SPE Reservoir Simulation Symposium, 23-25 February 2015.

[2] M. A. Murad, T. D. Le, and P. A. Pereira, ”Bridging Between Macroscopic Behavior of Shale Gas Reservoirs and Confined Fluids in Nanopores”, 14th ECMOR Conference, 2014.

[3] N. Frih , J. E. Roberts, A. Saada, ”Modeling fractures as interfaces: a model for Forchheimer fractures”, Computational Geosciences, **12**, 91-104, 2008.

[4] I. Y. Akkutlu, E. Fathi, ”Multiscale gas transport in shales with local kerogen heterogeneities”, Society of Petroleum Engineers, **17**(04), 1002-1011, 2012.