Journal of Petroleum & Environmental Biotechnology

OPEN ACCESS Freely available online

Mini Review

Analysis of Parameters Influencing Shale Gas/Shale Oil Reservoir Complex Fractures Network Construction

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ABSTRACT

Shales reservoirs have a high degree of anisotropy due to the presence of natural fractures (NFs) and also the orientation of beddings. Thus, hydraulically induced fractures (HFs) interact with natural fractures and build a network of fractures with complex morphology. The construction of a network of fractures significantly increases the conductivity of the formation, as it connects previously isolated fractures and pores, thus increasing the productivity index of the wells and providing greater economic viability in the shale gas/oil reservoir designs. This work presents the main parameters that have influence on the fractures generated in shales, aiming to understand their effects in shale rock and avoid problems in of the hydraulic fracturing design.

Keywords: Shales reservoirs; Hydrocarbon; Oil reservoirs; Poisson's coefficient

INTRODUCTION

The generation of oil occurs in sedimentary basins such as lakes, oceans, rivers and marshes, where sedimentary rocks with large amounts of fine grains, clay and silt are deposited over millions of years and carrying a certain volume of organic matter accumulated in the interior of their pores, Such rocks are called source rocks [1]. After the maturation of the organic matter present in the source rock, a natural fracture occurs in the same one, due to the conditions of high pressure and temperature, generating the primary migration of the hydrocarbon for its later imprisonment in a rock with high permo-porous properties, denominated rock reservoir.

The next step of the conventional petroleum system generating mechanism is to surround the reservoir by means of traps and a sealant rock, i.e., with low permeability, e.g. evaporite (salt) or shale itself, thereby preventing the hydrocarbon be drained to other layers. The shale gas/shale oil system is different from the conventional reservoirs (CR) mentioned above, since shales are part of a group known in the literature as non-conventional reservoirs (NCR), because the primary migration hasnot yet occurred and also, because the shales have low permo-porous properties. Thus, the drilling operation is done directly on the source rock, so the shales are classified as source-reservoir rocks (SRR) [2].

By around 2012, more than 55,000 wells have been drilled in shale gas reservoirs in the USA and as many wells are drilled for the development of an area, reducing the cost of well construction is an important aspect to be considered in a project of exploration and development of the production of shale gas/oil reservoirs, especially when the selling price of the gas/oil falls.

The main challenge of petroleum engineering for the exploration and production of shale gas/oil reserves is that their geomechanical properties are very different from conventional reservoirs. The development of numerical methods that simulate the behavior of the network of complex fractures in shale gas/shale oil reservoirs has been a huge challenge among engineers of stimulation and researchers of the petroleum industry in the last decade. As previously mentioned, the traditional models used in conventional reservoirs do not adequately reproduce the behavior of the fracture network in shales [2].Thus, unconventional models for the adequate modeling of the problem take into account the effects of very low permeability, high heterogeneity and also anisotropy of the formations [2-4].

Parameters Influencing Shale Gas/Shale Oil Reservoir Complex Fracture Network Construction Fracturability

For a hydraulic fracturing operation in shales to be successful, it is necessary that the rock possess great fracturability property, i.e. the skill of the shale to propagate the dominant fracture with several secondary fractures connected to it, in order to obtain the highest volume value of stimulated reservoir. High fracturability is associated with friable shale regions, with high modulus of elasticity and low Poisson ratio. Under these conditions a wide and stable fracture network is created. The low fracturability occurs in ductile regions of the shale, with low modulus of elasticity and high values of Poisson's coefficient. In these regions, the network of fractures is largely closed due to deformation, since it is a region with greater ductility [4].

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Received: February 03, 2021, **Accepted:** February 17, 2021, **Published:** February 24, 2021

Citation: Fernando BF, Breaga MB (2021) Analysis of Parameters Influencing Shale Gas/Shale Oil Reservoir Complex Fractures Network Construction. J Pet Environ Biotechnol. 12:417.

Net Pressure

The net pressure, i.e., the difference between the injection pressure of the fracture fluid and the difference of the horizontal stresses of the rock, has direct correlation with the construction of the network of complex fractures, since the higher the liquid pressure, the greater the extension of the network of fractures. Olson & Dahi- Taleghani (2009) showed that the net pressure directly influences the construction of the network of complex fractures. Normally the analysis of the influence of the liquid pressure on the interaction between hydraulic fractures and natural fractures is carried out by means of the net pressure coefficient.

Dynamic Viscosity of the Fracturing Fluid

The dynamic viscosity of the fracturing fluid in shales has a direct influence on the construction of the fracture network, because as the viscosity of the fluid increases, the extent of the fracture network is significantly reduced. Experimentally, it has been found that a high viscosity fracturing fluid contributes to the generation of the planar fracture pattern and a low viscosity fluid, such as slickwater fracturing, generates the network pattern of complex fractures. Thus, compared to conventional hydraulic fracturing, slickwater fracturing achieves higher SRV.

Pumping Rate

Gomaa investigated the influence of the fracture fluid pumping rate during the hydraulic fracture operation using slickwater in shales and realized that the increase in flow rate provided a reduction in the fracturing pressure of the sample [3]. In a hydraulic fracturing project in shale gas/shale oil reservoirs, the mechanical properties and mineralogical composition of the rocks are of great importance, considering that for the estimation of fracture pressure it is necessary to know the gradient of over bourden, horizontal stresses, modulus of elasticity and Poisson's coefficient. These parameters, related to the mineralogical composition, provide the coefficient of rock fragility[5].

Horizontal Stress Field

Ren found experimentally, through a triaxial test in a naturally fractured medium that the HF propagates along the NF to low values of horizontal stress difference and crosses the natural fractures to high values of tension difference horizontal, generating change in the behavior of the network of complex fractures [6-8].

The shale's britileness is directly correlated with its mineralogy, modulus of elasticity and Poisson's coefficient. As the concentration of feldspar, quartz and calcite containing silicon or calcium increases, clay concentration decreases and increases the brittleness of the rock, i.e. it reduces its capacity to undergo deformation under the action of tensile stress in the elastic regime. As the rock fragility increases, natural fractures occur due to compression efforts of the upper layers, generating more easily a network of complex fractures by means of the hydraulic fracturing operation with the use of low fracture fluids dynamic viscosity, e.g. slickwater fracturing. The volume of clay in the rock matrix is on average more than 30% of the sample and this quantity limits the volume of gas inside the shale pores, making the rock more ductile. Thus, the HF extends mainly in a simple plane of fracture similar to the conventional model in two wings instead of a network of fractures [7].

CONCLUSIONS

This work showed that for the stimulation of a given payzone of shale gas/shale oil by means of the construction of a complex network of fractures, several geomechanical, hydraulic and geometric parameters are directly correlated.

In this way it was verified that:

The higher the net pressure coefficient the higher the SRV.

In fragile shale gas/shale oil reservoirs, with low values of dynamic viscosity of the fracturing fluid, the construction of the network of complex fractures occurs with greater ease.

As the pumping flow of the fracturing fluid increases, the pressure required fracturing the formation decreases, but in the field, high pressure values are applied to ensure that the formation is fractured. With this, there is a need to hire more trucks equipped with high pressure pumps, increasing the CAPEX of the project.

The operational sequence and intervals between fractures influence in the construction of the network and increase of the SRV, since neighboring fractures disturb the field of tension of the formation, generating the stress effect shadowing, causing a curvature in the fractures located in the ends of the spacing between fractures and reducing the size of the fracture located at its midpoint due to the reorientation of the stress field in the vicinity of the generated fractures and reducing the permeability of this stimulated region. This reorientation of the tensile field also provides a change in the propagation direction of the HFs.

ACKNOWLEDGMENTS

I thank God, my dad Antonio Carlos Fernandes (In Memoriam), my mom Rosa Maria Bastos Fernandes, my dear wife Danielle Salles Sampaio and our daughter Meg. To Pontif´ıcia Universidade Cat´olica do Rio de Janeiro (PUC-Rio) and PETROBRAS.

REFERENCES

1. Huc AY. Paleogeography, Paleoclimate, and Source Rocks. A Assoc Pet Geolo. 2012.
2. Belyadi H, Yuyi S, Junca-Laplace JP. Production analysis using rate transient analysis. InSPE Eastern Regional Meeting. Soc Pet Eng. 2015.
3. Gomaa AM, Qu Q, Nelson S, Maharidge R. New insights into shale fracturing treatment design. InSPE/EAGE European unconventional resources conference and exhibition. Eur Assoc Geosci Eng. 2014;2014(1):1-15.
4. Zongxiao R, Xiaodong W, Dandan L, Rui R, Wei G, Zhiming C, et al. Semi-analytical model of the transient pressure behavior of complex fracture networks in tight oil reservoirs. J. Nat. Gas Sci. Eng. 2016;35:497-508.
5. Cheng Y, Lee WJ, McVay DA. Quantification of uncertainty in reserve estimation from decline curve analysis of production data for unconventional reservoirs. J. Energy Resour. Technol. 2008;130(4).
6. Li J, Guo B, Ling K. Flow diverting for reducing wellbore erosion in gas-drilling shale gas wells. J. Energy Resour Technol. 2013;135(3).
7. Warpinski N, Kramm RC, Heinze JR, Waltman CK. Comparison of single-and dual-array microseismic mapping techniques in the Barnett shale. InSPE Annual Technical Conference and Exhibition. SPE. 2005.
8. Zhao J, Chen X, Li Y, Fu B. Simulation of simultaneous propagation of multiple hydraulic fractures in horizontal wells. J Pet Sci Eng. 2016;147:788-800.