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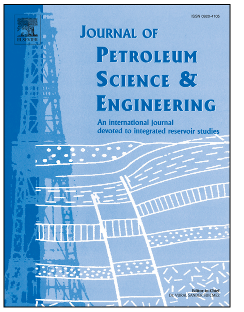

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Mohammed A. Sayed, Ghaithan A. Al-Muntasheri, Feng Liang

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Development of Shale Reservoirs: Knowledge Gained From Developments in North America

Mohammed A. Sayed[1], Ghaithan A. Al-Muntasheri[2], Feng Liang[1]

1) Aramco Services Company: Aramco Research Center-Houston, Houston, TX, USA

2) EXPEC Advanced Research Center, Saudi Aramco, Dhahran, Saudi Arabia

Abstract

The international daily increase in energy demands requires exploration of new and unconventional energy resources. Unconventional oil and gas have received special attention in recent years as an important source of fossil fuel. This is true especially in North America; United States and Canada, and in other regions in the world including the Middle East.

The technological advancements have made the production from unconventional resources possible and more economical. The learning curve and a substantial experience are being developed in North America, where most of the shale developments took place. This paper presents an effort to summarize the current experience on shales of North America from different aspects: rock mechanics, rock/fluids interaction, gas flow mechanisms through shale rocks, proppant embedment and water recovery after shale fracturing.

Shales rocks are composed of rock matrix, kerogen, and natural fractures. The mineralogy of shale rocks changes from one field to another. This change in mineralogy will impact the mechanical properties of the shale reservoirs. For example, Haynesville shale becomes more ductile with the increase in its clay content. Similar trends were seen for Lower Bakken shale, while other shale reservoirs, like Eagle Ford, Barnett and Middle Bakken contain more quartz and calcite, which make the rocks harder and easier to fracture. The rock mechanical properties of shale rocks can change as a direct result of the exposure of these clay-sensitive rocks to fracturing fluids. This has been confirmed in literature where Middle Bakken shale lost 52% of its Young's modulus after exposure to slickwater at 300°F for 48 hours.

Porosity in unconventional reservoirs can be found in both organic and inorganic parts of the rock. The porosity of the organic matter, and hence the amount of gas stored in kerogen, cannot be neglected and should be considered in the calculation of the gas originally in place. Porosity in organic matter depends on several parameters; among the most important ones is the maturity of the shale itself. Flow of gas in shale rocks is governed mainly by the non-Darcy effects. In addition, gas can be stored and produced from different sources including natural fractures, organic matter and inorganic matrix. Porosity and permeability in organic matter cannot be neglected and it is very important when it comes to storage and flow in shale reservoirs.

As a direct result of using different fluid systems in hydraulic fracturing of shale reservoir, an impact on the rock mechanical properties of the rocks were noticed and recorded. This impact can be significant based on several parameters like the temperature, time to exposure and the mineralogy of the shale rock itself. The rock properties can change in a way the rock becomes more ductile and that can increase the proppant embedment in the rock and the overall fracture conductivity to decrease.