Unconventional Shale Frackability – Effect of Porosity and Pore Shapes

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ABSTRACT

Hydraulic fracturing is a common practice used to dramatically improve the production of hydrocarbons from unconventional shale reservoirs. However, it is still not clear how micro-cracks initiates, grows, interacts and coalesces into macro-fractures in unconventional shales. This paper presents an experimental study investigating the effects of porosity and pore shapes on the crack generations and development. A better understanding of their effect on the frackability of unconventional shales will be useful in shale reservoir characterization and development, hydraulic stimulation design and other aspects of unconventional development.

Fracking increases the surface area of shale reservoirs and provides the flow channels for hydrocarbons extraction. This is usually achieved by pumping fracking fluids into the rock to initiate and propagate cracks under tension. A large proportion of the energy required for crack initiation and propagation is consumed in the crack initiation stage.

The presence of a stress-concentrating feature reduces the crack initiation energy. During fracturing cracks propagate through the inhomogeneous rock matrix, which consists of grains of various minerals and pores present in the rock. Once a crack hits a pore, its tip blunts. To propagate any further the crack has to reinitiate, which is an energy intensive process. The exact amount of energy required however, largely depends on the shape of the pores, as sharp corners within the pores act as stress concentrators, resulting in reduction in the energy for crack re-initiation.

In this paper, we used our state of art instruments to perform rock compressional tests on various shale samples from various basins in the world. The samples are imaged and then analyzed before and after tests to determine the size, the number, and the shape of pores present within samples. A model based on statistical methods is developed to describe the effects of total number, size and shapes of pores on crack propagation. To simplify the model, some assumptions are made and verified experimentally. This model will be helpful in optimization of fracking jobs in the oil and gas industry.