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Role of Geomechanics on Clastic and Carbonate Tight Reservoirs: A Middle Eastern Perspective

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ABSTRACT

An economically producible tight reservoir would have few typical characteristics: (1) Reservoir rock has potentially high hydrocarbon content (sweet spots), (2) It gets fractured and exhibits deeply propagated and well contained hydraulic fracture in order to have sizeable "Stimulated Reservoir Volume, SRV" and (3) It is able to deliver significant volumes of hydrocarbons efficiently from the reservoir to the well through the fracture with limited production decline rate. Deliverability of such reservoir can be high if it constitutes abundant natural fractures that can flow under in-situ stress.

While few drivers like 'richness of sweet spots' and 'deliverability of reservoir' are given and uncontrollable (though they can be evaluated), other drivers like 'optimal well placement' and 'optimal frac placement' are definitely under our control. When a good quality reservoir gets best well placement and a deeply propagated hydraulic fracture with good containment, the result can be delivery of a successful well.

What makes a tight rock frackable?

A successful stimulation job places the fractures deep enough into the reservoir from wellbore so that sufficiently large volume of reservoir rock could be stimulated. In addition, the fracture should stop growing into the bounding formations above and below the reservoir. Therefore, the final fracture geometry is seriously influenced by geomechanical setting of the reservoir rock although propagation of the fracture is driven by fluid injection rate and rheology. Below are key points in frac placement.

• Stronger rocks have higher compressive strength, so higher tensile strength too. This property of the reservoir can result resistance to breakdown.

• Brittleness of different rocks can be driven by many drivers. While sand/quartz content enhances brittleness, clay enrichment reduces it. Overall, mineralogy and textural fabric (cement type and grain size distribution) of a rock type play vital role in rock mechanical behavior of a reservoir. Understanding these drivers of brittleness is the key to characterize tight reservoirs.

• Deeper propagation of the fracture away from the wellbore is controlled by the bounding formations with sufficient contrast in terms of stress, rock strength, Young's modulus and Poisson's ratio.

• The presence of natural fractures in the fracturing intervals can possibly help initiation and propagation of hydraulic fractures.

Operator can link the formation properties and stress setting for efficient design of fracture job in number of ways: (1) Optimal selection of perforation interval, (2) Choice of perforation phasing (oriented vs unoriented), (3) Type of perforations, (4) Type and volume of frac fluid and (5) Type of proppants.

It is possible to have a systematic ranking criteria to quantify fraccability of a formation based on all drivers mentioned above. This presentation will go over such workflow.

Drilling and Fracturing are not two different operations in Tight Reservoirs:

Operations teams see drilling and fracturing as two different operations. These are clearly independent operations in case of conventional reservoirs where reservoirs flow by themselves without any stimulation. However, the tight reservoirs cannot flow without stimulation/fracturing. It was experienced from past decade in the Middle East and other areas that quality of borehole plays substantial role in defining success or failure of a stimulation job. A cylindrical borehole without breakouts/washouts can enhance the success of fracturing job. It was learned that poor quality borehole can lead to number of subsequent operational challenges, sometimes leading to failure of fracture propagation. It was witnessed in number of occasions that a poor hole quality/geometry results in poor quality logs, poor formation evaluation and compromised sweet spots identification. In addition, a poor quality hole do not allow good cementation of casing pipes, leading to inefficient perforations thereby ineffective propagation of hydraulic fracturing. Role of hole quality on fracturing success becomes more apparent in case of horizontal wells especially oriented to minimum horizontal stress (Shmin). Good quality borehole is a pre-requisite for formation evaluation as well as fracturing operations. Upon improving the communication between drilling and fracturing disciplines, mutual requirements could be better understood for a successful drilling and fracturing jobs.

Real-Time Geomechanics to bridge the gap between Drilling & Fracturing Disciplines:

Innovative real-time geomechanical monitoring methods can be customized and deployed based on formation behavior to monitor the borehole during drilling operations in order to manage the borehole quality as well as risk of hole instability. After drilling, performing a wireline based micro-fracturing provides pilot experience of a fracturing job and provides estimates of minimum horizontal stress magnitudes. Moreover, robustness of a geomechanical model can be further enhanced with these measurements in order to help drill wells in good geometry and also for better frac execution.

Simulating the Response of Complex Reservoirs during Fracturing:

In general, complexities in the reservoir due to field structure, geology and facies are not necessarily captured in frac simulations due to number of reasons. These reasons could be due to (a) limitations of simulation capabilities, (b) lack of sufficient data, (c) insufficient characterization of the reservoir or (d) inaccurate estimation of stress regime. As a result, actual fracturing design gets simplified (sometimes oversimplified) during simulations, leading to less reliable outcome. It is now possible to capture reservoir complexities in frac simulations with advanced methods in an integrated fashion. Such methodology with systematic calibrations can forecast more realistic behaviors of reservoir rock during stimulation, thereby reliable frac geometry and production forecast.