Geomechanics for Unconventionals Series, Vol IV:

The 'Complexity' Paradigm: Shifting Our Understanding in Order to Optimize Completions in Unconventionals

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'Complexity', when it comes to hydraulic fracture stimulations in Unconventional plays, is considered a good thing. But what is 'complexity', why is it a good thing, and, more importantly, why are so many folks convinced it can be generated?

The concept of 'complexity' was really born from the need to explain the often near-symmetric cloud of microseismicity seen when hydraulic fracturing in plays like the Barnett. Whereas the conceptual model of hydraulic fracturing said that a created hydraulic fracture would be planar and bi-wing (and would exhibit a bi-planar pattern of microseismicity from the wellbore), much of the early field data on microseismicity from Unconventionals showed a highly dispersed, decidedly non-planar, pattern. The concept of shear stimulation – the slippage along natural fractures and weakness planes generating shear microseismic events - was then developed to explain the highly dispersed microseismic behavior seen in so many Unconventional plays. Further, this shear stimulation was envisioned to enhance the permeability along the natural fractures and weakness planes thereby increasing production from the stimulation. Given the often ultra-low permeability of many Unconventional plays, the potential permeability increases represented by shear stimulation, and the apparent evidence of more and/or better shear stimulation with highly dispersed, complex, microseismic patterns, 'complexity', and the desire to generate it, became a central focus of many hydraulic fracture designs.

The challenge for completions designs in Unconventionals, and a challenge for the industry as a whole, is that the paradigm of being able to create 'complexity' is false. Rather, 'complexity' is a fundamental characteristic of the formation and the focus of completions design must be to take advantage of this characteristic (both during play assessment and during completions) in order to optimize value.

There are several keys to understanding hydraulic fracturing, but four stand out:

1) when hydraulic energy (via pressurized frac fluid) leaves the wellbore (the last place we have control over it), it will always take the path of least resistance;
2) a hydraulic fracture forms only when the flow rate from the well into the formation exceeds the flow capacity of the formation (i.e., the hydraulic fracture forms to take the injected fluid volume that the formation cannot take without fracturing);
3) net pressure – the difference between the fluid pressure inside a hydraulic fracture and the minimum principal stress – is the primary metric for the amount of work being done to the formation while hydraulic fracturing; and

4) the tensile strength of most formations is +/- 10% of the shear strength of the formation (i.e., the tensile strength is +/- 1/10th that of the UCS value).

What does this have to do with Unconventionals and 'complexity'? First, the hammer we have to break the formation is net pressure – and net pressure for many situations is only 200 to 300 psi (and an order of magnitude or more smaller than the UCS value of the formation). Second, when we use that hammer (net pressure), the formation is going to tend to fail in tension rather than shear (i.e., the formation is weaker in tension, ergo a tensile hydraulic fracture will be created). Third, the created tensile hydraulic fracture will (in a normal faulting stress environment) tend to grow vertically and propagate toward the maximum horizontal principal stress (SHmax) as this is the path of least resistance. Finally, the created hydraulic fracture will stop growing when the formation can handle the rate of fluid injected – either because the pumps have been shut down and no fluid is being injected or because leakoff into the formation matrix and/or natural fractures exceeds the injection rate; however, the hydraulic fracture path will remain the path of least resistance unless that path is blocked in some fashion.

In essence, these conditions all but preclude our ability to generate 'complexity' and the hydraulic fracture design process must focus on taking advantage of the weak planes and natural fractures in order to achieve the maximum 'complexity' potential of a given formation.

So how do we take advantage of the formation characteristic of 'complexity'? Visit the OFG website (www.ofgeomech.com) for a list of our publications on the geomechanics of Unconventionals as well as information on our 'Geomechanics for Unconventionals' training course in which we teach the fundamentals of 'complexity', hydraulic fracture optimization in Unconventionals, and the important geomechanical issues with refracturing in Unconventionals.

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