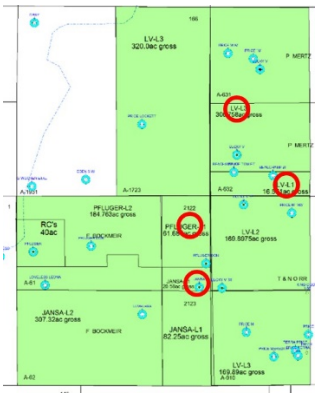
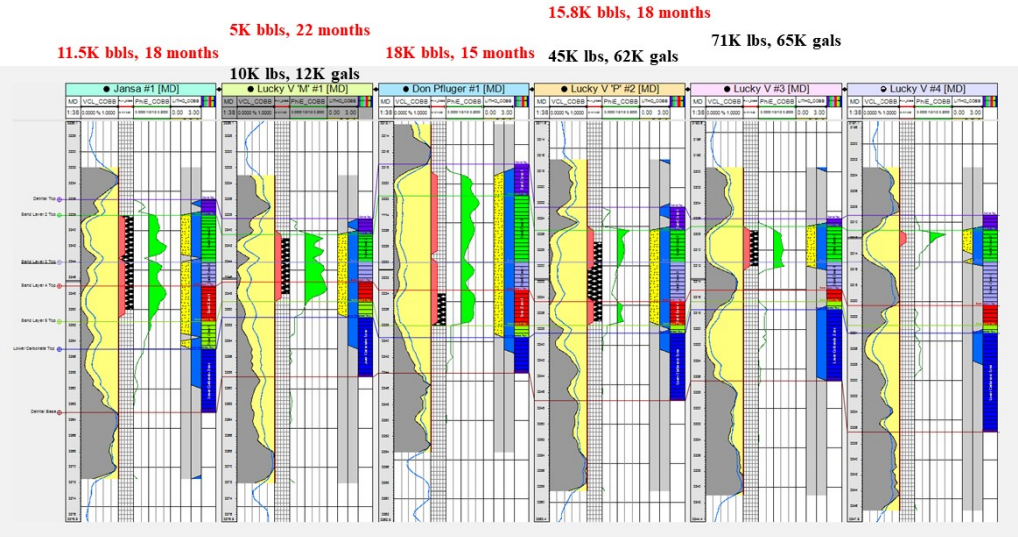
Systematic Approach to Completion and Exploitation Optimization – Vertical Well Example



History

The operator acquired this lease with many uncertainties including the extent, productivity, continuity and quality of conventional pay. The lease had one productive well with at least 2 other potential locations. This sandstone pay showed 2 lobes on the logs and offered as perforation targets. The operator drilled its first well and fracked it with Gen 1 design which turned out to be economic. For the next well, a step out to slightly north in the lease (a risk without delineation), they increased the fluid and proppant concentration, which also turned out to be a good well. The 2 wells had very little water production apart from flow back water. The third well was drilled somewhere in the middle of these 2 wells, thought to be relatively less risky, but with 3 times the proppant concentration and fluid volumes. Unfortunately, this well produced water with very little oil. Water volumes exceeded the flow back water. The well could not be restored even with water shutoff treatments.

At this point, the operator desired to undergo diagnostics to ascertain causes for this variability in production, carefully examine the next drill locations, settle on an optimized fracking program and investigate potential for waterflooding.



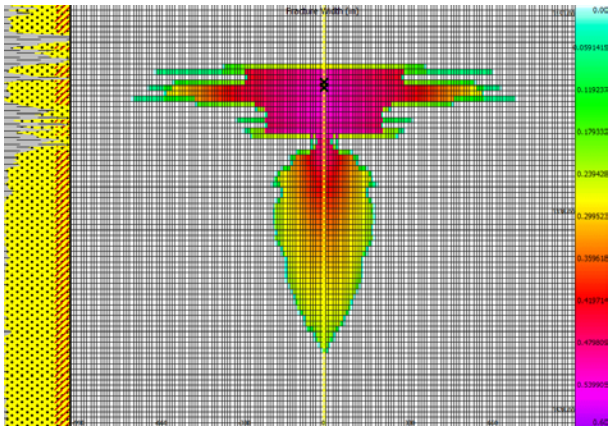
Problem

The engineering study probed several open questions including the following:

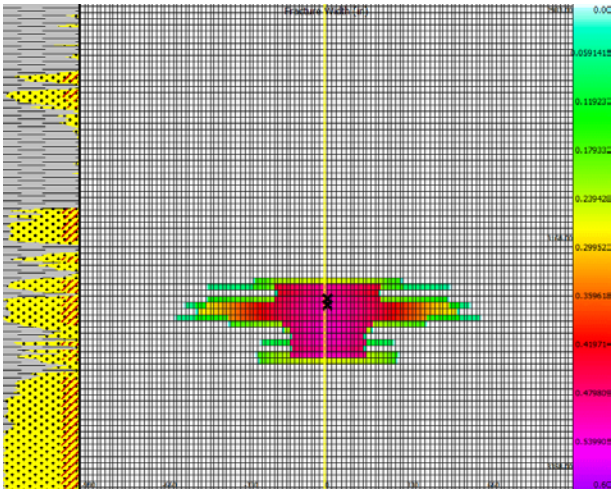
- ✓ Why wells perform differently?
- ✓ Why the bigger frac wells are not better?

- ✓ Why some wells produce more water than others?
- ✓ Why water production exceeds 100% load recovery in some wells?
- ✓ Why produced water salinity is different?
- ✓ Can we perforate remaining pay in some of the wells?
- ✓ Can we fracture them?
- ✓ If so, what is the optimal design?

Diagnostics



Fracture diagnostic study systematically models the fractures based on the process parameters used (rate, proppant concentration, fluid volumes, proppant type etc.) and the fracture attributes examined. It was clear that as the fracking got more aggressive i.e. higher rate, proppant concentration, fluid volume etc. the fracture has a tendency to grow vertically downwards out of pay and perhaps connects to some of the vertical fissures creating a continuity with water bearing formations below. This may be the cause of excessive water production in one of the wells.



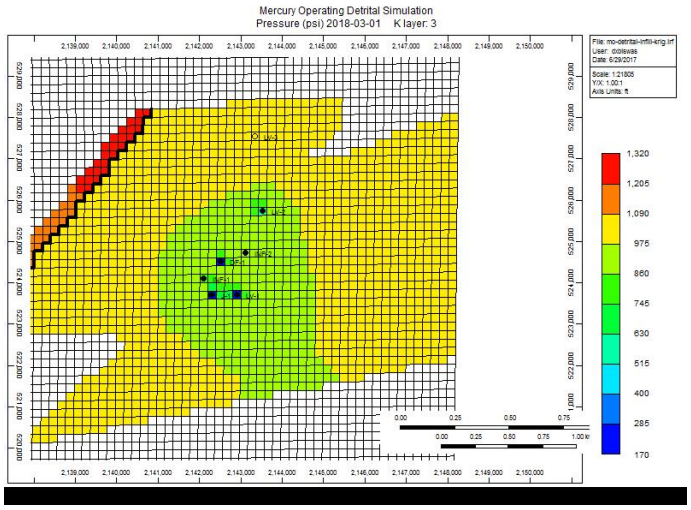
As a remedial measure, several sensitivities are run varying the process variables to compare the altering fracture attributes e.g. fracture width, baseline conductivity, proppant concentration etc. As an example,

Case x: Fluid System – Xlinked Gel, Proppant – 40/70 and 20/40, Concentration – 0.5, 1, 2, Pump rate – 15 bpm, Proppant mass – 28 K, Fluid volume – 3 K gals

Case y: Fluid System – SW, Proppant – 20/40, Concentration – 0.5, 1, 3, Pump rate – 9 bpm, Proppant mass – 11 K, Fluid volume – 14 K gals

The goal was to converge on a design which will have the most impact on fracture conductivity within the pay yet restrict itself from funneling downwards.

Solution



Armed with an acceptable completion design, the next challenge was to prescribe de-risked (at least with ranking) new infill drill locations. Using the typical geomodeling workflow encompassing petrophysical, geological and engineering history matching (around 3 years of existing production), reliable maps of pressure depletion, netpay and saturation maps are created. By inspecting and comparing these maps, additional 2 well locations are prescribed. These wells are once again successful. Using the incremental data acquired in these wells, the geomodeling workflow is further enhanced and 2 other well locations are suggested. Currently, operator is implementing this plan. In the future, the challenge will be to assess the northern extent delineation of the field.