geoconvention
Calgary • Canada • May 13-17 2019

Optimization of Hydraulic Fracture Design Parameters, Using Multivariate Statistical Analysis with Integration of Unconventional Fracture Modeling (UFM) and Calibrated Production Data, A Montney example

Majid M. Faskhoodi, Drazenko Boskovic, Alexey Zhmodik, Li Qiuguo, Oscar P. Michi, Venkateshwaran Ramanathan, Raouf Ameuri, Schlumberger

More than 5000 wells have been drilled in Montney since 2010. Most of these wells are completed, using standard very similar completion design, without any consideration to reservoir quality, pressure regime on the area or if the well is placed in simple or complex structure area or the well is on dry, wet or oil area. The million-dollar question is if a single design could be effective everywhere and every time or it needs to be optimized for each well. In this paper, we present a novel approach in optimizing the hydraulic frac design parameters based on reservoir characteristics (binning).

Advanced logs from vertical wells and 3D-seismic were used to build integrated geological model. None-uniform Discrete Fracture Network (DFN) model was constructed. 3D geo-mechanical model was built and initialized, using sonic log and seismic data. Statistical analysis was done for all available wells in geological model to find the most influential geological parameters that impact deliverability of wells. Results from single point statistical analysis were further extended to unsupervised discrete classification using neural-network to bin the reservoir. Hydraulic fracture modeling was completed by utilizing actual pumping schedule and was calibrated against micro seismic for validation. Dynamic model was constructed, utilizing frac model and calibrated against historical production data. History matched model was then used as predictive tool to optimize various frac parameters for each classification.

Each well was assigned with sets of input variable and target data and multivariate analysis was done to find correlation between these two. **Figure-1** presents list of input variable and target data. Input variables with high correlation coefficient with target data were identified (**Figure-2**). Key production influencing variables were utilized to create unsupervised discrete classification at well location, using neural-network. 3D unsupervised classification model (6-classes) was then established, utilizing these variables from well point data model, to create regions/bins probability maps (**Figure-3**). 5 synthetic wells were placed in each class (bin) and frac design parameters were optimized individually. Different fracture design parameters such as proppant tonnage, fluid type/proppant size, cluster spacing, number of cluster per stage and pumping rate were considered for sensitivity analysis. Hydraulic frac modeling followed by dynamic modeling was done for all cases. Same modification from history matched model was imposed to all models. Frac geometry, hydraulic and propped surface area, and frac conductivity were extracted and compared. EUR, Initial production, short term and long term cumulative production were plotted and analyzed. Optimum frac parameters were selected for each bin by considering both acceleration and incremental recovery with respect to base case, and cost of frac job.

For the first time, a reservoir quality (RQ) dependent optimized frac design parameters were established. This novel approach provides specific design for a specific reservoir classification (reservoir quality-RQ) through entire reservoir and eliminates the need of doing optimization for every single well.

- Input Variable
  - Reservoir Properties (from 3D Static Model)
    - Poro / Perm / SHMin / Delta Stress / Pore Pressure / Distance to Fault / Ant (Max, Ave, Count)
    - SW / Density / VCL / TOC / Vol of Carb / YMOD / SHMax / PR / AI / MuRo / Curvature
- Target (Observed data)
  - qi / q3 / q12 / decline rate / 1Y Cum Gas Prod /1Y Cum BOE / EUR

Figure 1

Target	Inupt Variable with High Correlation Coefficient			
	Reservoir Properties	Corr Coeff	ANT	Corr Coeff
Rate	VCL	0.68	Ave ANT Value	0.6
	Porosity	0.56	Max ANT	0.5
	Permeability	0.52		
	Vol of Carb	0.47		
	Curvature	-0.36		
	AI	-0.39		
	Sw	-0.45		
	YMOD	-0.53		
	Delta Stress	-0.55		
Gas Prod & BOE (1Y Cum)	VCL	0.65	Ave ANT Value	0.6
	Porosity	0.49	Max ANT	0.5
	Permeability	0.47	# of ANT Event >0.25	0.5
	Vol of Carb	0.41		
	Curvature	-0.36		
	AI	-0.36		
	Sw	-0.37		
	YMOD	-0.44		
	Delta Stress	-0.49		
	Distance to Fault	-0.51		
EUR	VCL	0.68	Ave ANT Value	0.6
	Porosity	0.63	Max ANT	0.5
	Vol of Carb	0.63		
	Permeability	0.6		
	Pore Pressure	0.48		
	Curvature	-0.48		
	Distance to Fault	-0.52		
	Sw	-0.57		
	YMOD	-0.62		
	Delta Stress	-0.64		

Figure 2

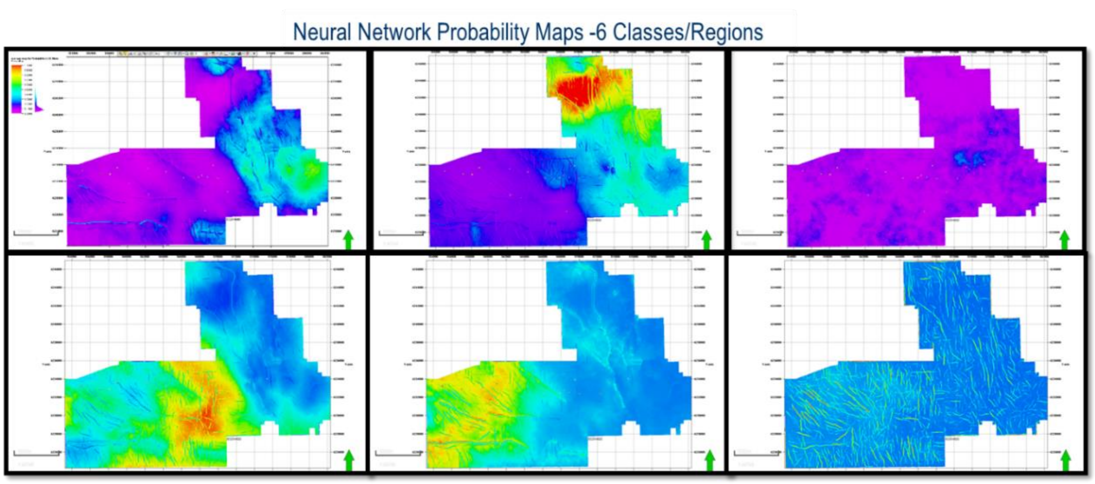

Figure 3