

SPE Hydraulic Fracturing Technology Conference 2016

The Woodlands, Texas, USA
9 – 11 February 2016

Volume 1 of 2

ISBN: 978-1-5108-3121-6

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

Copyright© (2016) by Society of Petroleum Engineers
All rights reserved.

Printed by Curran Associates, Inc. (2016)

For permission requests, please contact Society of Petroleum Engineers
at the address below.

Society of Petroleum Engineers
P. O. Box 833836
Richardson, Texas 75083-3836

Phone: (800) 456-6863
Fax: (972) 952-9435

books@spe.org

Additional copies of this publication are available from:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571 USA
Phone: 845-758-0400
Fax: 845-758-2633
Email: curran@proceedings.com
Web: www.proceedings.com

TABLE OF CONTENTS

Volume 1

Acoustics-Based Flow Monitoring During Hydraulic Fracturing	1
<i>C. Stokely</i>	
Advanced Modelling of Interwell Fracturing Interference: An Eagle Ford Shale Oil Study - Refracturing.....	25
<i>A. Morales, K. Zhang, K. Gakhar, M. Porcu, D. Lee, D. Shan, R. Malpani, T. Pope, D. Sobernheim, A. Acock</i>	
The Application and Misapplication of 100-mesh Sand in Multi-Fractured Horizontal Wells in Low-Permeability Reservoirs	44
<i>W. Al-Tailji, K. Shah, B. Davidson</i>	
Calibrated Complex Fracture Modeling Using Constructed Discrete Fracture Network from Seismic Data in the Avalon Shale, New Mexico	72
<i>F. Ajisafe, M. Thachaparambil, D. Lee, B. Flack, K. Hemsley, E. Ejofodomi, C. Taylor</i>	
Case Histories in Cost-Efficient Re-Fracturing of Horizontal Wells.....	91
<i>J. Matt</i>	
A Case Study of Completion Effectiveness in the Eagle Ford Shale Using DAS/DTS Observations and Hydraulic Fracture Modeling.....	101
<i>B. Wheaton, K. Haustveit, W. Deeg, J. Miskimins, R. Barree</i>	
Comparison of Pseudo-3D and Fully-3D Simulations of Proppant Transport in Hydraulic Fractures, Including Gravitational Settling, Formation of Proppant Banks, Tip-Screen Out, and Fracture Closure.....	112
<i>S. Shiozawa, M. McClure</i>	
Completion Optimization in the Fayetteville Shale Utilizing Rate Transient Analysis for Candidate Selection.....	137
<i>B. McDonald, T. Wright</i>	
Computational Fluid Dynamics Applied to Investigate Development and Optimization of Highly Conductive Channels within the Fracture Geometry	144
<i>A. Gomaa, H. Hudson, S. Nelson, H. Brannon</i>	
Correlating Water Hammer Signatures with Production Log and Microseismic Data in Fractured Horizontal Wells	162
<i>M. Carey, S. Mondal, M. Sharma, D. Hebert</i>	
A Coupled Geomechanics and Fluid Flow Modeling Study for Hydraulic Fracture Design and Production Optimization in an Eagle Ford Shale Oil Reservoir.....	177
<i>J. Curnow, A. Tutuncu</i>	
Determining the Effectiveness of Isolation Techniques Using Completion Diagnostics and Production Analysis.....	189
<i>C. Senters, D. Snyder, M. Warren, R. Leonard, R. Woodroof</i>	
Dry Polyacrylamide Friction Reducer: Not Just for Slick Water.....	209
<i>M. Sanders, K. Felling, S. Thomson, S. Wright, R. Thorpe</i>	
Effect of Horizontal Stress Models and Biot Poro-Elasticity on Predicted Fracture Geometry	222
<i>S. Narasimhan, H. Shaikh, J. Gray, B. Cherian, O. Olaoye, R. Rifai, K. Kublik, M. McCleary, S. Fluckiger, M. Sharf-Aldin</i>	
Effect of Perforation Geometry and Orientation on Proppant Placement in Perforation Clusters in a Horizontal Well.....	241
<i>C. Wu, M. Sharma</i>	
Eight-Plus Years of Hydraulic Fracturing in the Williston Basin: What Have We Learned?	264
<i>K. Srinivasan, J. Krishnamurthy, R. Williams, P. Dharwadkar, T. Izykowski, W. Moore</i>	
Engineering Solid Particulate Diverter to Control Fracture Complexity: Experimental Study	284
<i>A. Gomaa, A. Nino-Penalosa, E. McCartney, J. Mayor</i>	
Evaluating the Relationship Between Well Parameters and Production Using Multivariate Statistical Models: A Middle Bakken and Three Forks Case History	303
<i>E. Lolon, K. Hamidieh, L. Weijers, M. Mayerhofer, H. Melcher, O. Oduba</i>	
Evaluation of Acid Fracturing by Integrated Pressure Analysis and 3D Simulation: A Field Application for Multi-Stage Stimulation in Horizontal Wells	331
<i>K. Ueda, W. Zhang, D. Zhu, A. Hill, F. Zhang, X. Yang</i>	
An Evaluation of Completion Effectiveness in Hydraulically Fractured Wells and the Assessment of Refracturing Scenarios.....	351
<i>J. Dahl, K. Dhuldhoya, R. Vaidya, J. Tucker, J. Samaripa, B. Johnson, R. Dusterhoff</i>	

Expanding Interpretation of Interwell Connectivity and Reservoir Complexity through Pressure Hit Analysis and Microseismic Integration.....	369
<i>J. Lehmann, J. Budge, A. Palghat, C. Petr, J. Pyecroft</i>	
A Family of Unique Diverting Technologies Increases Unconventional Production and Recovery in Multiple Applications - Initial Fracturing, Refracturing, and Acidizing.....	389
<i>E. McCartney, R. Kennedy</i>	
Fiber-Optics Results From an Intra-Stage Diversion Design Completions Study in the Niobrara Formation of DJ Basin	408
<i>M. Ramurthy, J. Richardson, M. Brown, N. Sahdev, J. Wiener, M. Garcia</i>	
First Application for a Sequenced Fracturing Technique to Divert Fractures in a Vertical Open Hole Completion: Case Study from Saudi Arabia	424
<i>K. Bartko, R. Tineo, G. Aidagulov, Z. Al-Jalal, A. Boucher</i>	
Fully-Coupled 3D Hydraulic Fracture Models: Development, Validation, and Application to O&G Problems.....	439
<i>K. Searles, M. Zielonka, J. Ning, J. Garzon, N. Kostov, P. Sanz, E. Biediger</i>	
Generic Correlations for Proppant Pack Conductivity.....	459
<i>R. Barree, J. Miskimins, M. Conway, R. Duenckel</i>	
The Good, the Bad and the Ugly: A Case History of a Multi Stage Hydraulic Fracturing Horizontal Well Tight-Gas Development in Oman.....	478
<i>A. Nicolaysen, A. Casero, A. Roy, M. Rylance, S. Kumiadi, T. Batmaz</i>	
High Concentration Polyacrylamide-Based Friction Reducer Used as a Direct Substitute for Guar-Based Borate Crosslinked Fluid in Fracturing Operations.....	499
<i>M. Motiee, M. Johnson, B. Ward, C. Graddl, M. McKimmy, J. Meeheib</i>	
Hydraulic Fracture Height Estimation in an Unconventional Vertical Well in the Vaca Muerta Formation, Neuquen Basin, Argentina	510
<i>A. Ortiz, D. Hryb, J. Martinez, R. Varela</i>	
Hydraulic Fracture Height Predictions in Laminated Shale Formations Using Finite Element Discrete Element Method.....	522
<i>H. Li, Y. Zou, P. Valko, C. Ehlig-Economides</i>	
Hydraulic Fracture Modeling Workflow and Toolkits for Well Completion Optimization in Unconventionals.....	539
<i>T. Bai, J. Will, S. Eckardt, D. Chang, E. Lake, A. Madyarov, X. Xiao, M. Fay, R. Meij, R. Yuan, Y. Gao, J. Chu</i>	
Identification of Activated Fracture Networks Using Microseismic Spatial Anomalies, b-Values, and Magnitude Analyses in Horn River Basin	564
<i>A. Yousefzadeh, Q. Li, C. Virues, R. Aguilera</i>	
Impact of Ash Beds on Production in Eagle Ford Shale.....	587
<i>J. Xu, K. Fisher, F. Qiu, R. Malpani, E. Ejofodomi, A. Viswanathan</i>	
Implications of Pressure-Induced Thinning in Crosslinked Fluids for Fracturing and Frac Pack Operations.....	598
<i>M. Fuller, K. Blake</i>	
Improved Frac Design and Reservoir Simulation Using Strain Derived from Geomechanical Modeling - Application to the Fayetteville Shale.....	615
<i>S. McKetta, S. Vargas-Silva</i>	
Improving Hydrocarbon Recovery in Sliding Sleeve Completions Utilizing Diverters in the Wattenberg Field	625
<i>J. Fry, E. Roach, B. Kreyche, T. Yenne, G. Geoffrey, M. Jespersen</i>	

Volume 2

Improving North Sea Fracturing and Stimulation Economics Through Increasing Innovation and Efficiency in Operations and Applications: Lessons Learned.....	635
<i>O. Ishteiwy, A. Doghmi, M. Rylance</i>	
Improving Understanding of Complex Fracture Geometry of the Canadian Horn River Shale Gas Using Unconventional Fracture Propagation Model in Multi-Staged Horizontal Wells	654
<i>C. Virues, I. Ehiriudu</i>	
Integration of Dynamic Microseismic Data with a True 3D Modeling of Hydraulic Fracture Propagation in Vaca Muerta Shale	666
<i>M. Haddad, J. Du, S. Vidal-Gilbert</i>	
Interpretation Methodology for Fracture Calibration Test Before-Closure Analysis of Normal and Abnormal Leakoff Mechanisms	695
<i>G. Liu, C. Ehlig-Economides</i>	

Interwell Hydraulic Fracture Interaction Between Multistage Stimulated Wells and a Multi Zone Slant Open Hole Observation Well Placed in the Canadian Horn River Basin	711
<i>J. Pyecroft, J. Lehmann, C. Petr, K. Lypkie, I. Purdy, H. Zafar, C. Hiller, D. Meeks</i>	
Khazzan: Making the Most of the Fracturing Sweet-Spot Between Verticals and Horizontals	727
<i>A. Shueili, A. Manji, M. Rylance</i>	
Lessons Learned From Refractured Wells: Using Data to Develop an Engineered Approach to Rejuvenation	745
<i>C. Li, J. Han, R. Lafollette, S. Kotov</i>	
Lessons Learned: Refracs from 1980 to Present	762
<i>B. Grieser, J. Calvin, J. Dulin</i>	
Mesh-Free Numerical Simulation of Pressure-Driven Fractures in Brittle Rocks.....	786
<i>T. Douillet-Grellier, R. Pramanik, K. Pan, A. Albaiz, B. Jones, H. Pourpak, J. Williams</i>	
Microseismic Closure Window Better Characterizes Hydraulic Fracture Geometry	805
<i>S. Liu, P. Valko, S. McKetta, X. Liu</i>	
Modeling Study of Acid Fracture Fluid System Performance	829
<i>M. Aljawad, D. Zhu, A. Hill</i>	
Novel Evaluation Method of Fracturing Fluid Additives on Barnett and Marcellus Outcrop Shale Cores Using NMR Technique	845
<i>J. Kim, A. Gomaa, H. Zhang, S. Nelson</i>	
Optimal Perforation Location and Limited entry design for Promoting Simultaneous Growth of Multiple Hydraulic Fractures.....	855
<i>C. Cheng, A. Bunger, A. Peirce</i>	
Perforation Cluster Efficiency of Cemented Plug and Perf Limited Entry Completions; Insights from Fiber Optics Diagnostics	875
<i>G. Ugueto, P. Huckabee, M. Molenaar, B. Wyker, K. Somanchi</i>	
Performance of Plugless Toe Stages and Non-Isolated Wellbore in Multi-Stage Hydraulic Fractured 10 Well Half Pad in the Canadian Shale Gas Horn River Basin	892
<i>C. Virues, A. Wang, J. Pyecroft, J. Lehmann, C. Petr, J. Hendrick, Z. Kuang</i>	
Physical Explanation of Non-Linear Derivatives in Diagnostic Fracture Injection Test Analysis.....	947
<i>R. Barree, J. Miskimins</i>	
Production Benefits from Complexity – Effects of Rock Fabric, Managed Drawdown, and Propped Fracture Conductivity	966
<i>L. Britt, M. Smith, H. Klein, J. Deng</i>	
Recent Advancements in Far-Field Proppant Detection	996
<i>T. Palisch, W. Al-Tailji, L. Bartel, C. Cannan, M. Czapski, K. Lynch</i>	
Relating Cement Bond Quality to Stage Communication in Horizontal Tight Sand Completions.....	1021
<i>J. Harpel, A. Brack</i>	
Remote Imaging of Proppants in Hydraulic Fracture Networks Using Electromagnetic Methods: Results of Small-Scale Field Experiments.....	1034
<i>D. Labrecque, R. Brigham, J. Denison, L. Murdoch, W. Slack, Q. Liu, Y. Fang, J. Dai, Y. Hu, Z. Yu, A. Kleinhammes, P. Doyle, Y. Wu, M. Ahmadian</i>	
The Science of Proppant Conductivity Testing- Lessons Learned and Best Practices	1050
<i>R. Duenckel, N. Moore, L. O'Connell, K. Abney, S. Drylie, F. Chen</i>	
The Search for Optimized Stimulation in Horizontal Wells: Coiled Tubing Fracturing, Lessons Learned from Bottomhole Gauges and Diagnostic Data	1070
<i>S. Stolyarov, R. Hurt, C. Thacker, P. Sookprasong</i>	
Sinuosity of the Hydraulic Fractured Horizontal Well Impact on Production Flow Assurance: An Eagle Ford Case	1084
<i>F. Qiu, G. Yuan, M. Marongiu-Porcu, J. Xu, T. Pope</i>	
Strategies for Effective Stimulation of Multiple Perforation Clusters in Horizontal Wells	1096
<i>R. Manchanda, E. Bryant, P. Bhardwaj, M. Sharma</i>	
Understanding Completion Performance in Niobrara-Codell Reservoirs Through the Use of Innovative Software-Guided Workflows and Models.....	1120
<i>K. Wallace, P. Aguirre, E. Jinks, T. Yotter, R. Malpani, F. Silva</i>	
Understanding the Applicability and Economic Viability of Refracturing Horizontal Wells in Unconventional Plays	1140
<i>G. Lindsay, D. White, G. Miller, J. Baihly, B. Sinosic</i>	
Unlocking Tight Chalk Potential in Mature North Sea Oilfield Through Effective Acid Fracturing	1159
<i>A. Doghmi, A. Davies, M. Rylance</i>	
A Validation Assessment of Microseismic Monitoring	1181
<i>N. Warpinski, S. Wolhart</i>	

Variable Pump Rate Fracturing Leads to Improved Production in the Marcellus Shale	1216
<i>J. Ciezbka, D. Maity, I. Salehi</i>	
Well Integrity for Fracturing and Re-Fracturing: What Is Needed and Why?	1227
<i>G. King, R. Valencia</i>	
A Well Performance Study of Eagle Ford Shale Gas Wells Integrating Empirical Time-Rate and Analytical Time-Rate-Pressure Analysis	1241
<i>A. Davis, T. Blasingame</i>	
Author Index	