ARMA Geomechanics for Unconventionals Workshop
(Agenda Update)

When: 8am to 5pm (0800-1700hrs) Saturday, June 27th

Where: Westin St. Francis, San Francisco

Key Features:

- A one-day format before the ARMA 2015 conference in San Francisco featuring industry experts making keynote-style presentation on critical, geomechanics-related aspects of Unconventional Developments.
- The workshop will consist of seven, one-hour (40 minutes presentation plus 20 minutes facilitated discussion) sessions.

Workshop Schedule:

Session 1: "The Rocks Matter: Optimizing Production from Unconventional Reservoirs" by Dr. Mark D. Zoback, Professor of Geophysics, Stanford University

In this talk, I present the results of several research projects investigating how rock properties, natural fractures and the state of stress affect the success of hydraulic fracturing operations during stimulation of shale gas and tight oil reservoirs. First, through laboratory measurements on samples of the Barnett, Eagle Ford, Haynesville and Horn River shales, I discuss pore structure and permeability as well as the impact of clay content on the viscoplastic behavior of shale formations. Second, I present several lines of evidence that indicates that one important way in which hydraulic fracturing stimulates production from shale gas reservoirs is by inducing slow slip on pre-existing fractures and faults, a process which is not detected by conventional microseismic monitoring. Finally, I discuss how hydraulic fracturing operations can be optimized in response to variations of rock properties in the context of the studies discussed above.

Session 2: "GeoMechanical Modeling of the Natural Fracture System and its Interaction with the Hydrofracturing Process" by Dr. Paul La Pointe, Manger of Upstream Petroleum Service, Golder Associates, Inc.

This session will describe the geomechanical impact of the natural fracture system on the hydrofracturing process, and illustrate the use of geomechanically-based Discrete Fracture Network models in the optimization of hydrofracturing design through case histories and field examples. The presentation will consist of four parts: 1) Why do we care? The Impact of Natural Fractures on Rates & Recovery; 2) Development of a Conceptual Basis for Natural Fracturing through GeoMechanics; 3) Discrete Fracture Network (DFN) Modeling of Natural Fractures; and 4) Use of DFN Models for Hydrofracturing Design Optimization with Field Examples

Session 3: "Numerical Modeling for Hydraulic Fracturing in Low Mobility, High Modulus Reservoirs" by Dr. John McLennan, Assoc. Professor of Chemical Engineering, University of Utah

Monoplanar hydraulic fracturing simulators are being gradually supplemented by modified commercial numerical packages. These newer simulations account for the presence of natural discontinuities and characterize hydraulic propagation in a multiplicity of natural and induced fractures. The calculations assess tensile and/or shear criteria – with or without significant associated width development. The user needs to comprehend the modeling methodologies and the input data required beyond what are used in simulations for propagation of a single planar entity.

Session 4: "Field Fracture Design Considerations and Methods for Unconventionals" by Ron Dusterhoft, Technology Fellow, Halliburton

For unconventional assets horizontal wellbores with multiple hydraulic fracture stages have become the normal completion solution, but there are a multitude of issues that are not yet well understood and can have a severe

impact on completion execution and well performance. The significance of wellbore placement as related to hydraulic fracturing and techniques that can be utilized to establish the optimum location for fracture location and fracture staging will be presented along with some of the pros and cons of perf and plug versus sliding sleeve completions in either open hole or cased hole will be discussed. Field operational considerations to validate geomechancial properties, reservoir characteristics and improve proppant distribution in complex fracture systems will also be presented.

Session 5: "Unconventional Play Reservoir Response" by Dr. Neal Nagel, Chief Engineer, OilField Geomechanics LLC

This presentation will focus on the expected and achieved reservoir response from Unconventionals with an emphasis on developing drainage area (SRV), the effect of Stress Shadows, and changes in drainage area with production. This will serve as a foundation for a discussion of frac stage and cluster spacing, well spacing, and the impact of multi-well completion schemes such as Zipper Fracs.

Session 6: "Fracture Diagnostics for Unconventional Reservoirs" by Dr. Norm Warpinski, Technology Fellow, Pinnacle-A Halliburton Service

A discussion of the fracture monitoring technologies that can be applied to understand and evaluate stimulations in unconventional reservoirs, including microseismic, microdeformation, fiber-optic sensing, and more conventional diagnostics. The discussion will include interpretation and integration of these technologies and application to engineering of optimized completions.

Session 7: "Shale Reservoir Re-Fracturing – The Geomechanics Impact" by Dr. Ibrahim S. Abou-Sayed, i-Stimulation Solutions, Inc.

Multi-fractured horizontal wells in shale plays exhibit, sometimes dramatic, performance declines due to deterioration in completion effectiveness. This decline is caused by one or more of the following physical processes: permeability, fracture conductivity, loss of effective fracture area, and reservoir rock creep. These processes cause an adverse impact on the effective fracture dimensions and are controlled by pressure changes. The decline in the well performance is controlled by the way we drawdown the wells especially in early times. Looking back at historical production practices suggests that the industry practices may have damaged the hydraulic fracture effectiveness. The damage starts at the wellbore and spreads deeper in the reservoir as production time increases. In order to overcome this decline in the effective fracture conductivity, refracturing is necessary. In this paper we discuss the impact of geomechanical parameters on drawdown and well performance. We also present a re-fracturing analog model, developed from a statistically significant dataset of over 80 wells in the Haynesville Shale, for estimating the probabilistic economic value, the potential uplift and the minimum threshold volume required. We also discuss methods to achieve this potential including implementation and early field data results.