# Keys to Successful Multi-Fractured Horizontal Wells In Tight and Unconventional Reservoirs

Presented by: Larry K. Britt NSI Fracturing & Britt Rock Mechanics Laboratory





#### **Key Questions for Horizontal Success**

- Where Do I Land the Horizontal Well?
- How Do I Complete The Well?
- Where Do I Complete The Well?
- How Many Completions Do I Need?
- How Do I Fracture Stimulate The Well?
- What Fracturing Fluid Do I Use?
- What Pump Rate Should I Use?

#### **Key Questions for Horizontal Success**

- Where Do I Land the Horizontal Well? Core
- How Do I Complete The Well? Permeability/Core
- Where Do I Complete The Well? Core
- How Many Completions Do I Need? Permeability
- How Do I Fracture Stimulate The Well? Core
- What Fracturing Fluid Do I Use? Permeability/Core
- What Pump Rate Should I Use? Core

\* Core Represents Mineralogy, Rock and Geomechanics

# Keys to Horizontal Success

- Design For Success Through Petrophysics
  - Ductility (Mineralogy, Rock & Geomechanics)

– Permeability

Completion(s) & Stimulation(s)
– Fracture Length & Lateral Length

• Execute, Execute, Execute

### **Presentation Outline**

- Historical Perspective: Horizontal Wells
- Horizontal Well Characterization & Objectives
- Basis of Water Frac Designs Ductility
- Permeability
- Geomechanics
- Summary

### **Horizontals: A Historical Perspective**



Metrics Used To Determine The Optimum Distance Between Fractures/Compleions



Effect Of Lateral Length On Completion Optimization



**Number of Fractures** 

Effect Of Fracture Length On Completion Optimization





### **Presentation Outline**

- Historical Perspective: Horizontal Wells
- Horizontal Well Characterization & Objectives
- Basis of Water Frac Designs Ductility
- Permeability
- Geomechanics
- Summary

#### **Basis of Fracture Design**



#### Schematic of a Water-Frac



Un-propped Crack Tests Integrate The Lab Results With The Field & Explains The Effect Of Poor Proppant Coverage!

#### Water Frac Guidelines Must Depend on Un-Propped k<sub>F</sub>w



# Why Un-Propped Crack Testing?



With Un-Propped k<sub>f</sub>w A Shale Reservoir Can Support Hundreds Of Feet Of Un-Propped Fracture!

This Is Why Water-Fracs Should Only Be Applied To Tight Unconventional Reservoirs & Proppant Is Always Needed!

### Water-Frac's Must Depend On Un-Propped Fracture Conductivity



Area 4,5, & 7 Represents Woodlawn & Blocker Fields Where Taylor (CV) Sand Is 100+ Feet Thick!



# Young's Modulus & Brittleness

#### Proppant And Fluid Selection & Quantity:

Young's Modulus



# **Un-Propped Crack Test & Ductility**

#### Proppant And Fluid Selection & Quantity:

**Un-Propped Crack Conductivity** 



#### **Basis of Fracture Design**



#### Water Frac Design Example



### Water Frac Design Example





#### **Barnett Design:**

Young's Modulus 4 x 10<sup>6</sup> psi 0.25 PPG Need 250 mgals 0.50 PPG Need 110 mgals 1.00 PPG Need 60 mgals

> Minimum Fluid Requirement Does Not Consider Dilation!

### **Presentation Outline**

- Historical Perspective: Horizontal Wells
- Horizontal Well Characterization & Objectives
- Basis of Water Frac Designs Ductility
- Permeability
- Geomechanics
- Summary



Dun E MMnei







### **Presentation Outline**

- Historical Perspective: Horizontal Wells
- Horizontal Well Characterization & Objectives
- Basis of Water Frac Designs Ductility
- Permeability
- Geomechanics
- Summary

#### **Geomechanics of Horizontal Wells**





What Is The Likely Fissure Direction In The Current Stress State Whereby:

- The Natural Fissures Are Open,
- The Fissures Are Conductive, And
- Potentially Contributory To Well Performance



The Object Of The Completion(s) & Fracture Stimulation(s) Is To Effectively Contact As

Much Reservoir As Possible:

Micro-Seismic Data Used To Assess Contacted
Volume Or Stimulated Reservoir Volume
Where:

SRV = L x H x W of Micro-Seismic Event Map Often  $2(x_f) \times H_f \times L_L$ 

#### **Stimulated Reservoir Volume**



#### If SRV Important How Do You Get More?



#### But Does Complexity Or Stimulated Reservoir Volume Add Up To Hydrocarbon Recovery



Additional Simulations Show That SRV May Not Be Critical Or Is It? What About Over The Long Term? Study Showed That SRV Not Very Effective, Neither Was Induced Fracture For That Matter



# Keys to Horizontal Success

- Design For Success Through Petrophysics
  - Ductility (Mineralogy, Rock & Geomechanics)

– Permeability

Completion(s) & Stimulation(s)
– Fracture Length & Lateral Length

• Execute, Execute, Execute