PPEPCA SEMINAR

“Untapping Tight Gas Reservoirs”

Pakistan Technology Forum

DESIGN & QUALITY CONTROL TECHNIQUES FOR OPTIMIZED FRACTURING OPERATIONS

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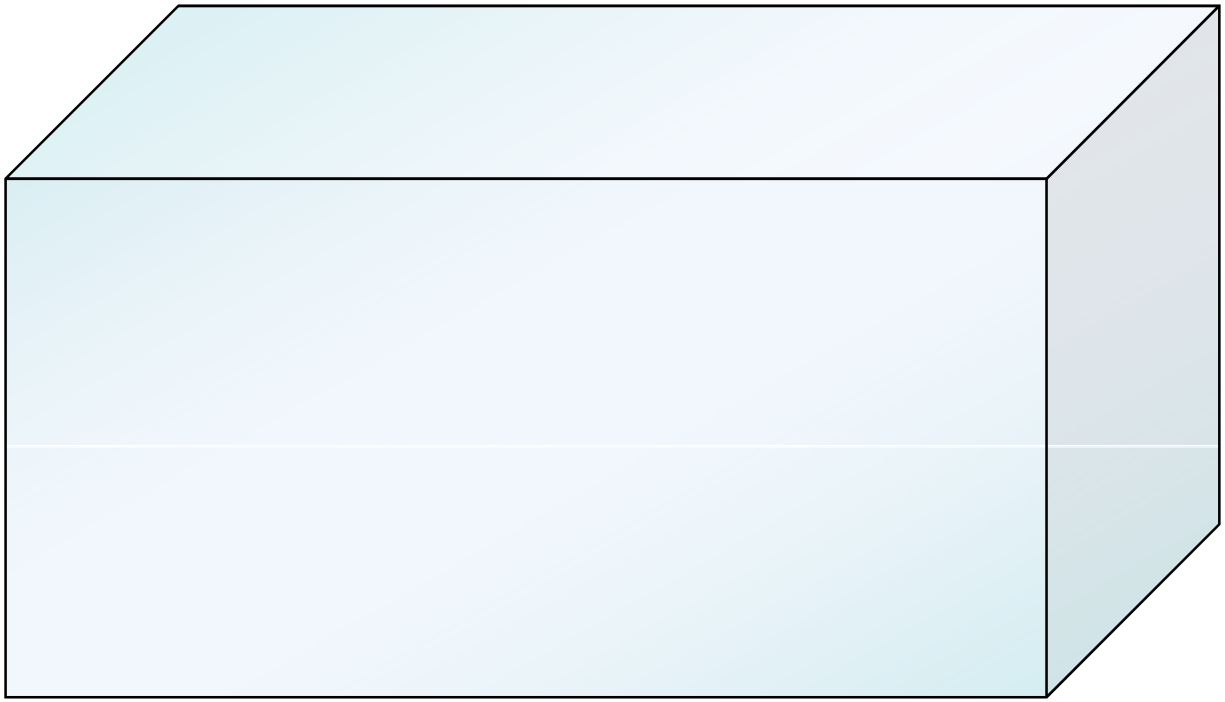
Overview

- Hydraulically fracturing low perm formations needed
- Fracture Design Keys to Success
- Lab Testing needs for pre job and location
- Post job recovery and testing
- Documenting and improving each time
- Scorecard to success

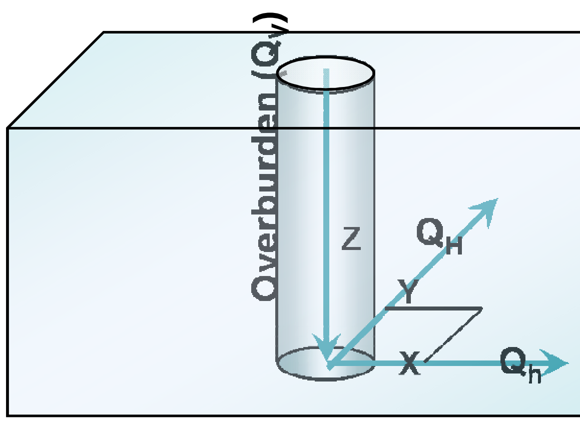
Fracture Design



Optimizing Fracture Design Is The First Key

Fracture Design – Key Considerations

- What is Hydraulic Fracturing and what are you trying to accomplish
- Must review and design each well even in same field
- Must have proper reservoir information for proper candidate selection
- Need to know pre and post production to grade success
- Fracturing Introduces permeability, i.e. a measurable contrast
- Proper design and implementation can result in a several fold increase in production. $$$

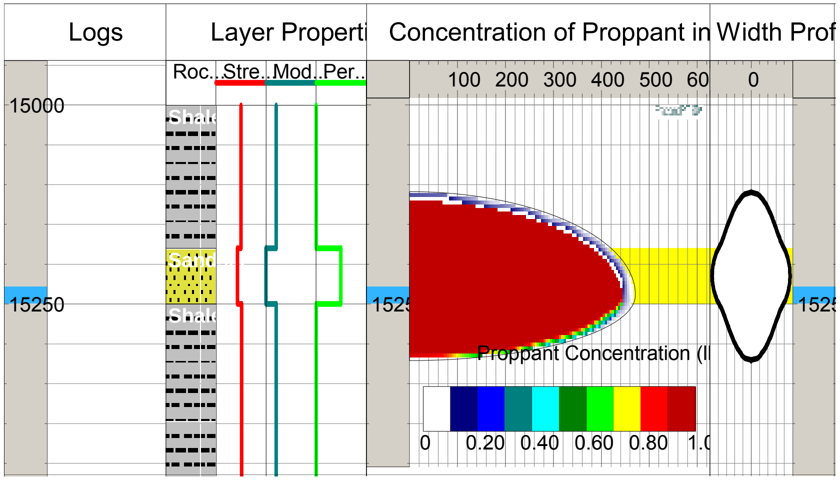


- **Principle stresses**
  - Q_V = Overburden
  - Q_H = Maximum Horizontal stress
  - Q_h = Minimum Horizontal stress
- **With a FRAC we try to get optimum Fracture length and width..**
  - …and extend the fracture past the near wellbore damage zone
  - Fractures normally grow perpendicular to the minimum Horizontal stress.
  - It helps to align perforations in the direction of the maximum horizontal stress
    - Rarely done

Fracture Design – Software & Analysis

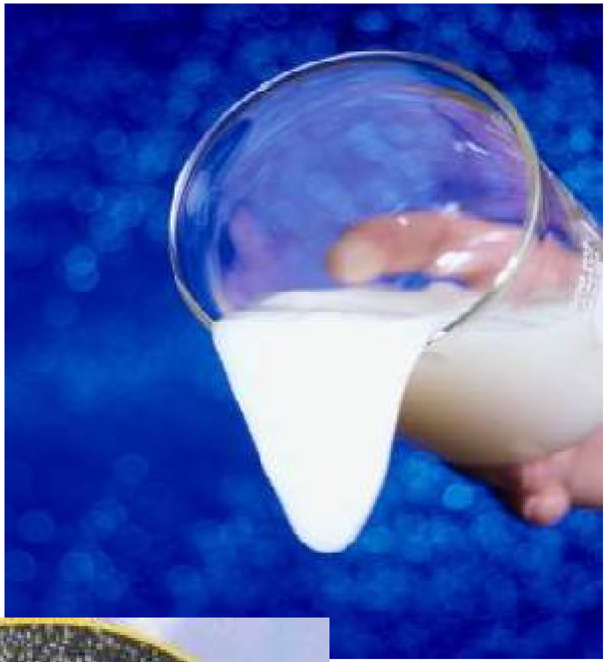
- For fracturing, effective modeling of the pumping operation is critical to success
- To insure maximum value; the jobs are optimized using analysis software and then real time treatment is modeled using design software such as FracPro, StimPlan, MFrac, etc.
- Running several iterations will insure that the job is not over or under designed.
- Minifrac analysis and redesign if necessary

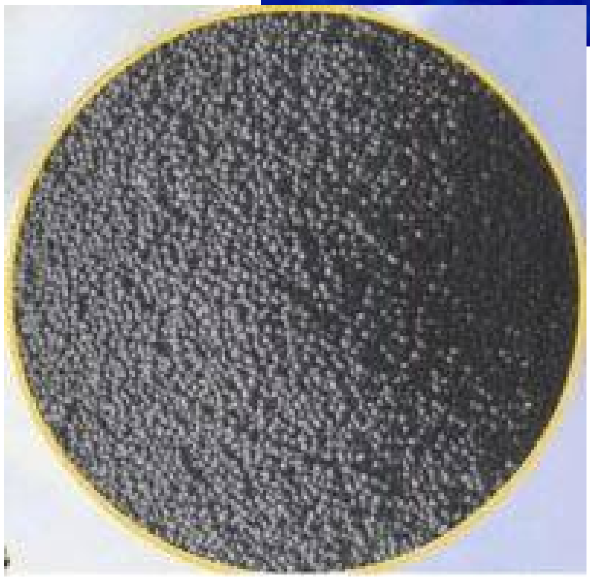
Fracture Half-Length (ft)	472	**Propped Half-Length (ft)**	446
Total Fracture Height (ft)	212	**Total Propped Height (ft)**	201
Depth to Fracture Top (ft)	15109	**Depth to Propped Fracture Top (ft)**	15121
Depth to Fracture Bottom (ft)	15321	**Depth to Propped Fracture Bottom (ft)**	15321
Equivalent Number of Multiple Fracs	1.0	**Max. Fracture Width (in)**	0.94
Fracture Slurry Efficiency**	0.46	**Avg. Fracture Width (in)**	0.54
		Avg. Proppant Concentration (lb/ft²)	2.13



Fracture Design - Fluid Systems & Proppants

- Wide variety of fracturing fluids
  - Guar based, Borate crosslinked fluid
  - CMHPG based, Zirconium crosslinked fluid
  - Visco Elastic Surfactants (VES)
- Breakers – “Be Aggressive”
  - Liquids, Solids, various temperatures
- Breakers should be tailored to each scenario
- Run temperature models for Optimum design
- Use information for proper lab testing





- Proppant Selection Process
  - Depth, Stress, Production Rates, etc.

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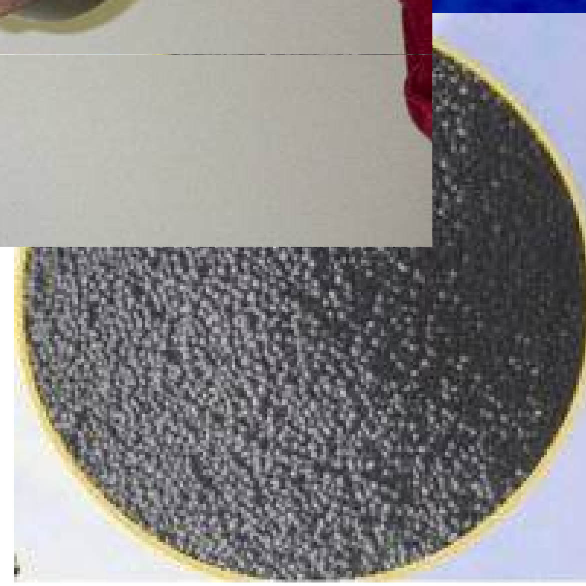

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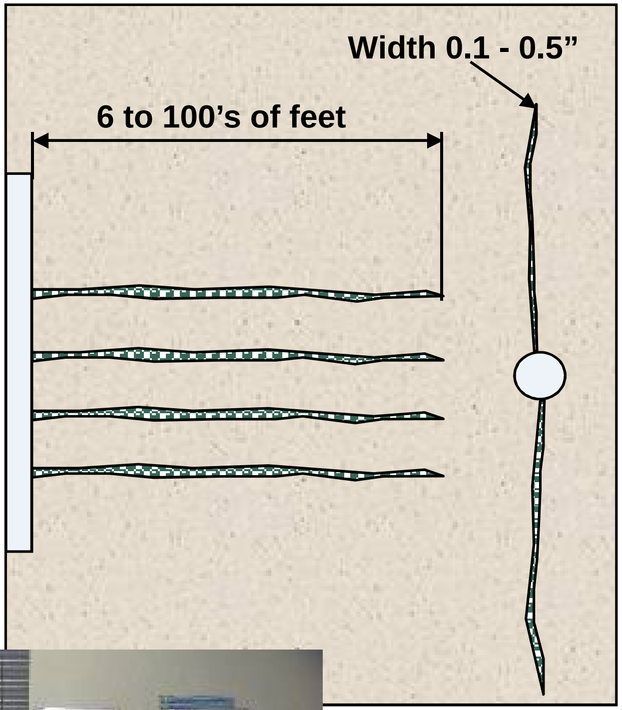
Fracture Design – Lab Design

- MUST simulate reservoir conditions
- Design fluids for optimum placement and clean pack after breaking
- Must perform testing prior to job in lab and also on location before job
- Need correct lab equipment and set up available near operations
- Qualify Proppants



Proper Chemicals Very Important

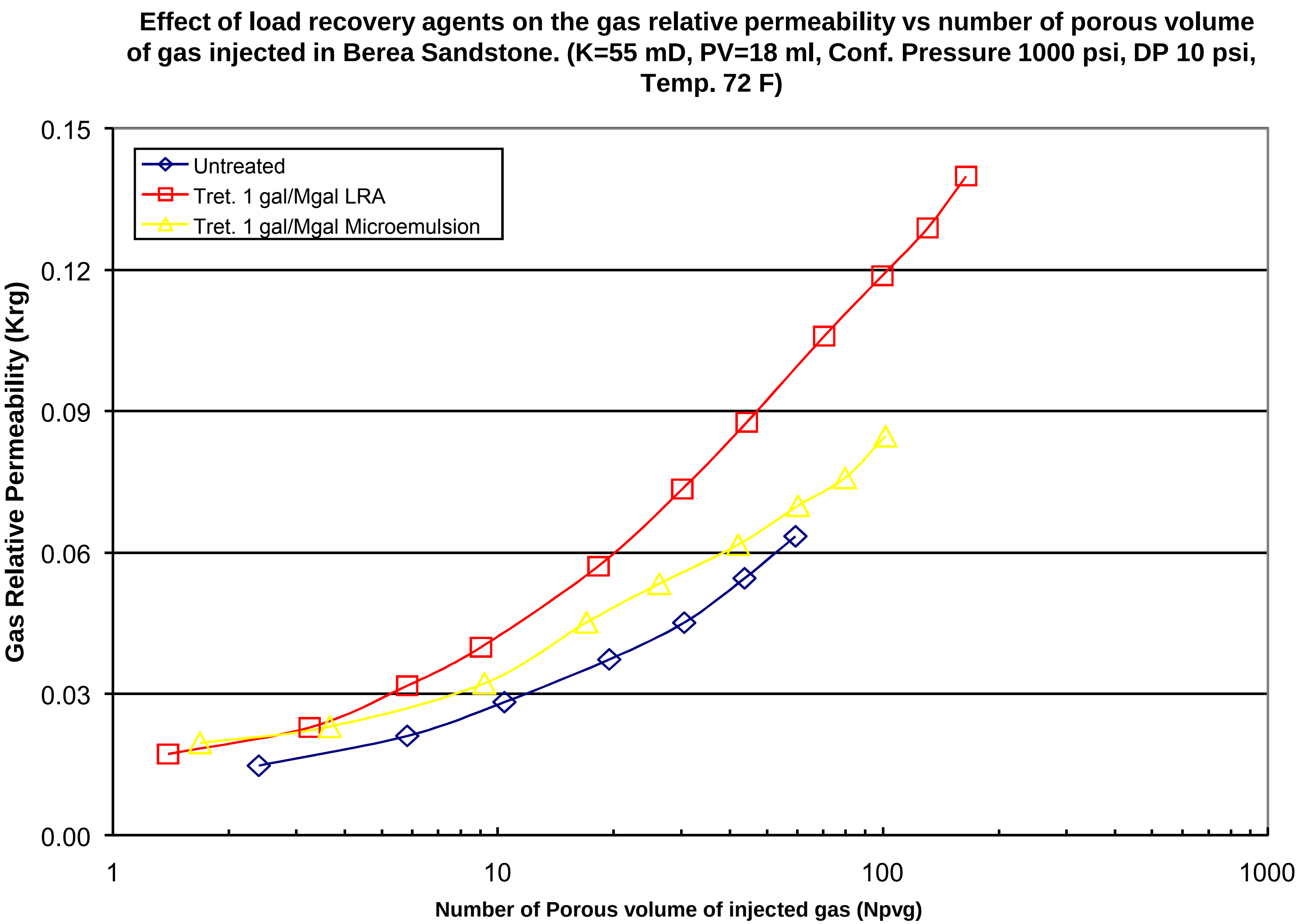
- Acid Corrosion Inhibitors
- Anti-Sludge Agents
- Bacteriacides
- Breakers
- Clay Stabilizers
- Crosslinkers
- Fluid Loss Additives
- Friction Reducers
- Gel Stabilzers
- Gelling Agents
- Solvents
- Iron Control Agents
- Mutual Solvents
- Oxygen Scavengers
- pH Control Agents
- Scale Inhibitors
- Surfactants - Defoamers
- Surfactants - Emulsifiers
- Surfactants - Fines Suspending Agents
- Surfactants - Foamers
- Surfactants - Non-Emulsifiers
- Wax / Paraffin Inhibitors

Fracture Design – Fluid Recovery

Load Recovery Agents provides these Benefits:

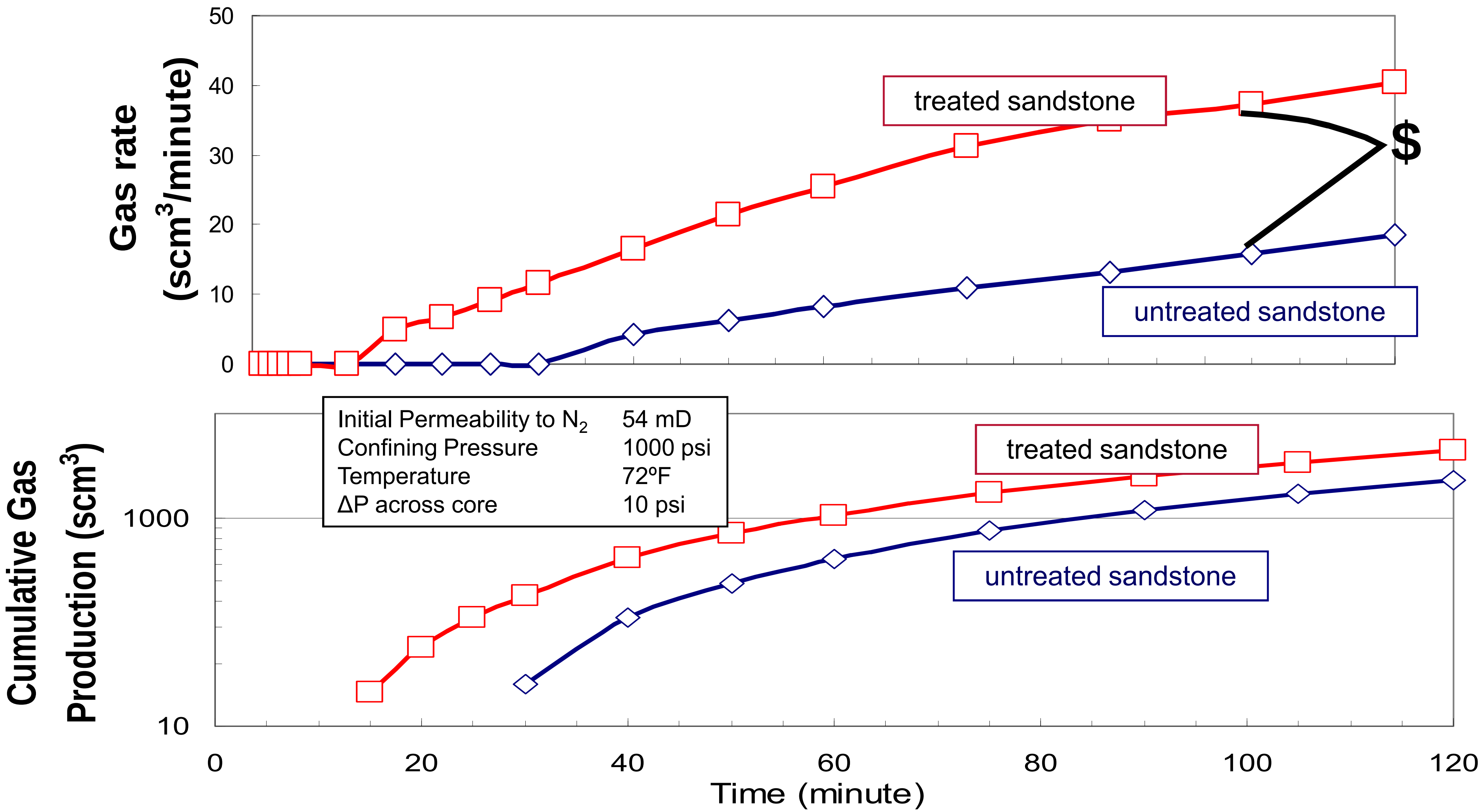
- Increase in the load recovery
- Higher relative Gas Permeability
- Changes in the wettability closer to neutral

Load Recovery Comparison



Load Recovery Makes A Difference

Improved Flow Rates and Load Recovery with LRA

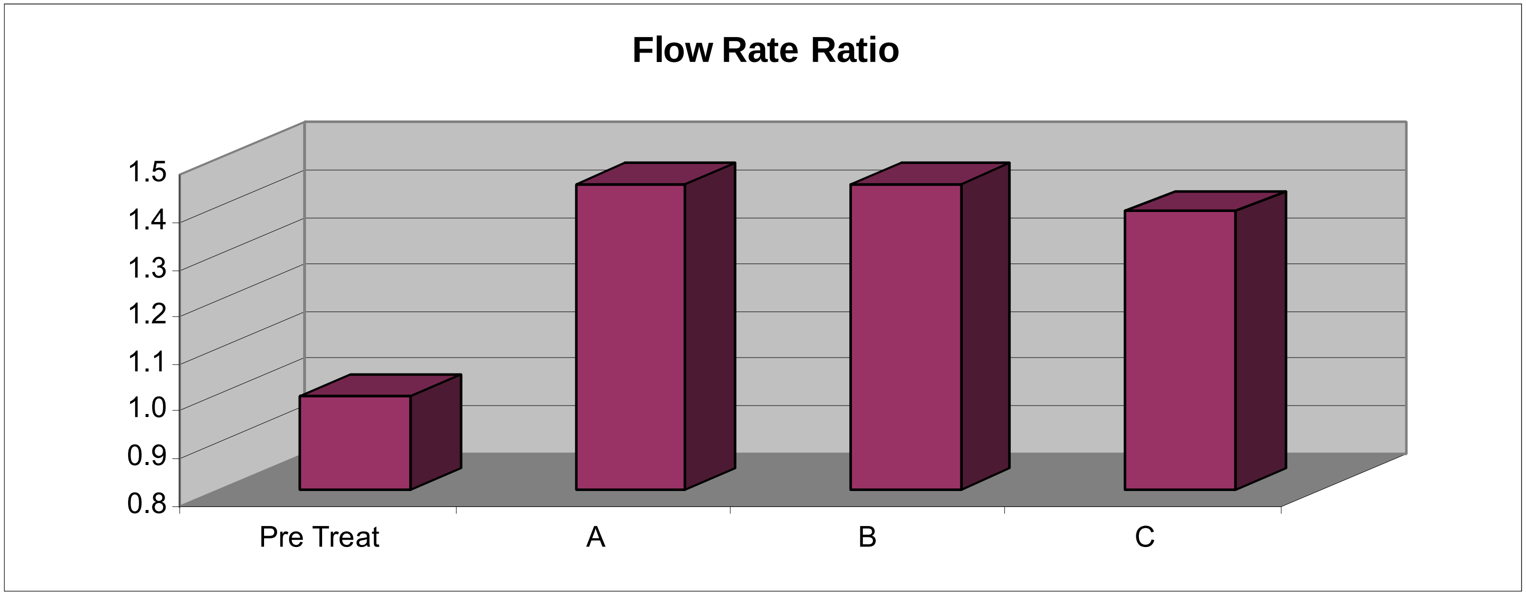


Equipment Requirements & Cost Considerations

- Fully Automated dependable equipment
- Frac jobs can require small to large footprints – right equipment essential
- Engineering Analysis of Real Time Data
- Proper procedure very involved and required
- Cost range

Production Increase Comparison

- Sustained increases range from 1 to beyond 10 fold increase
- Tight Gas production success requires fracture stimulation
- Production results



Key Conclusions for Consideration

- Fracture designs can be complex but tools available to aid success
- Tight gas reservoirs require stimulation for success
- Proper fluid and chemical packages lead to success
- To be successful, recognize all wells are not alike
- Simulate reservoir conditions for success
- Fracs designed for NPV and not purely economics more successful
- Proper planning insures highest level of success
- Expected increases from 1, 2, 5, 10, … times equal success

QUESTIONS & ANSWERS