International Perforating Forum
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Perforating Symposium

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An Evaluation of the Impact of Reactive Perforating Charges on Acid Wormholing in Carbonates

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Agenda

Background

Objectives

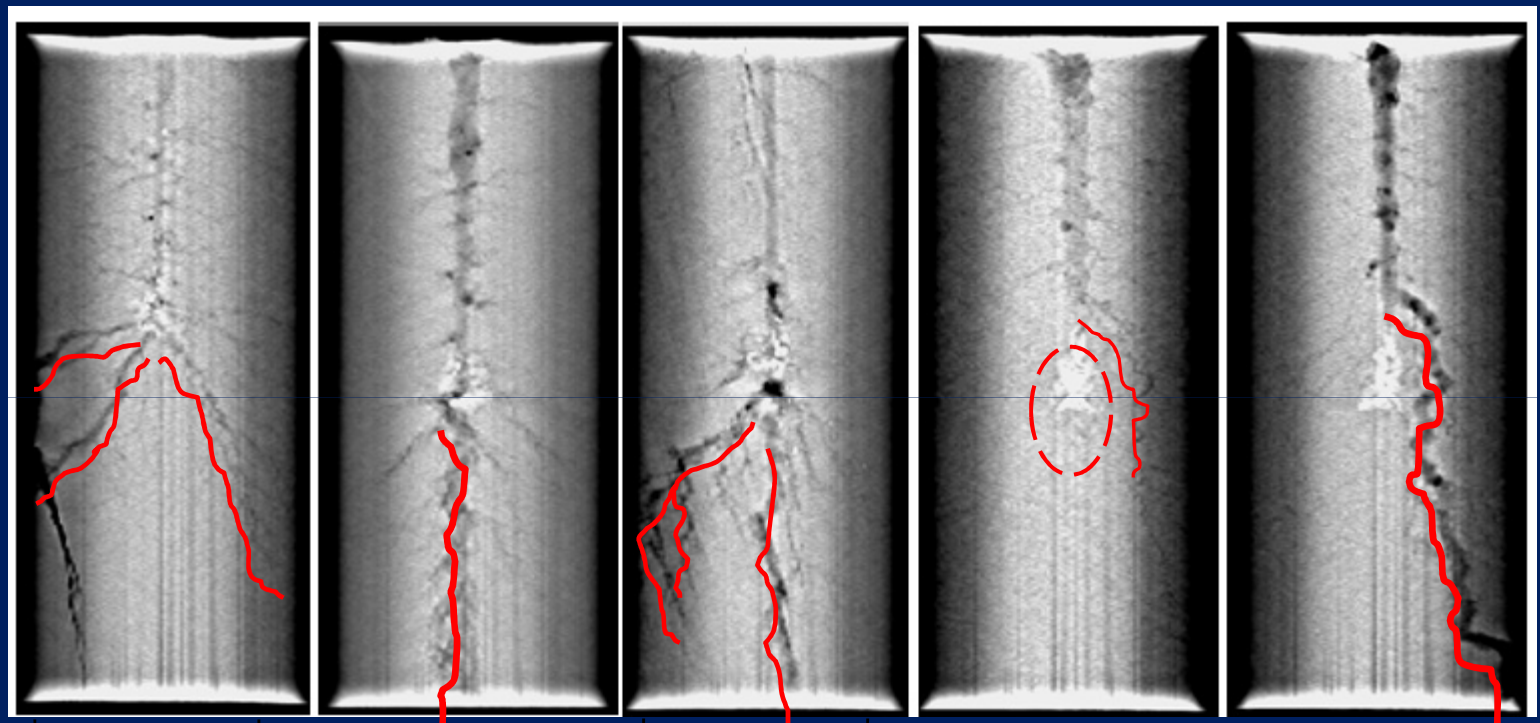
Experimental Procedure and Parameters

Results

Conclusions and Recommendations

Background

CT Scan images of acidized cores (Bartko et al. 2007. SPE 105022)



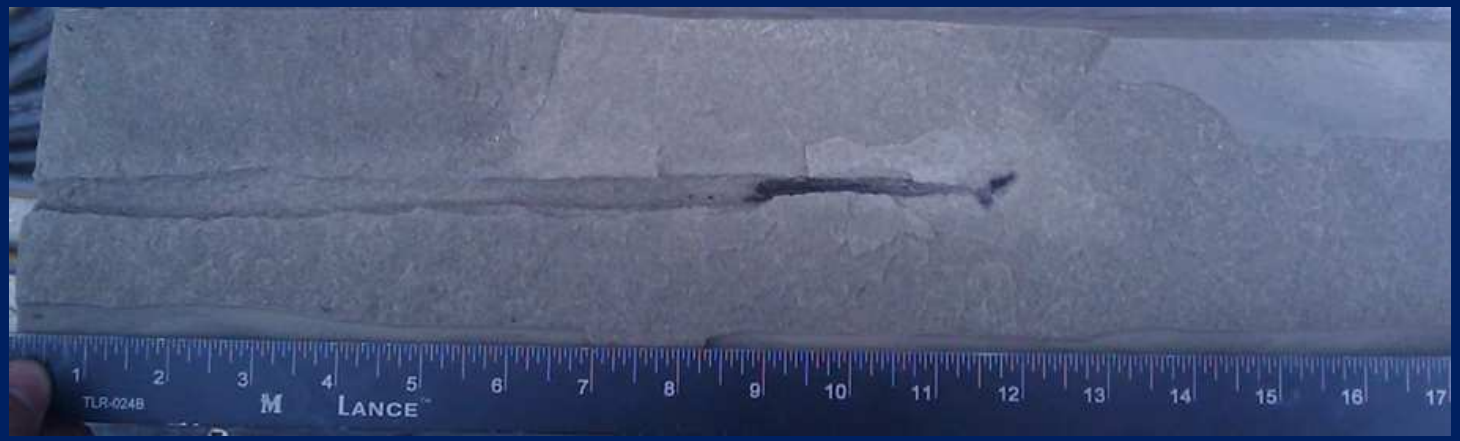
Static Underbalanced P_{inj}=3600 psi

Dynamic Underbalanced P_{inj}=2700 psi

Gas-filled Wellbore Balanced P_{inj}=2500 psi

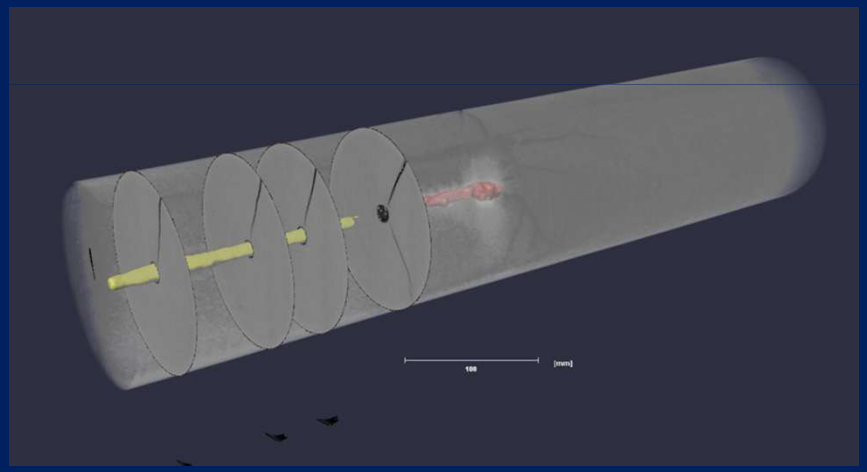
Acid-filled Wellbore Dynamic Underbalanced P_{inj}=90 psi

Perforation Geometry

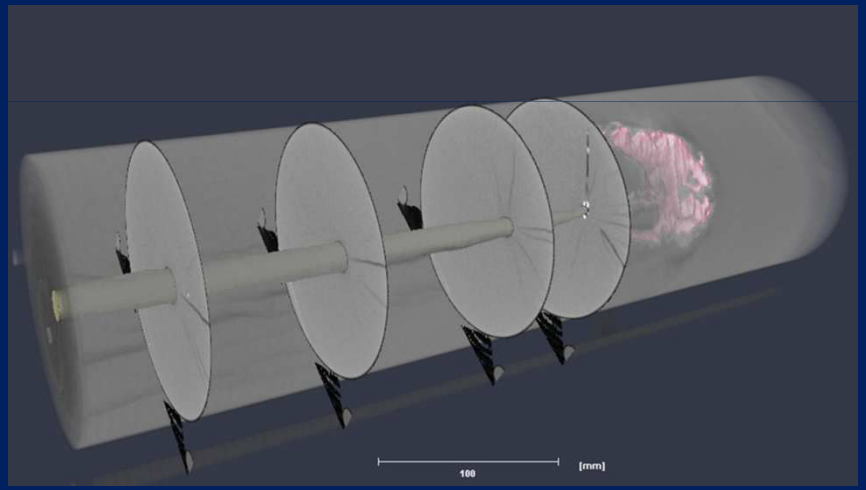


Background

Conventional 25g



Reactive 25g



Background

Advantages:

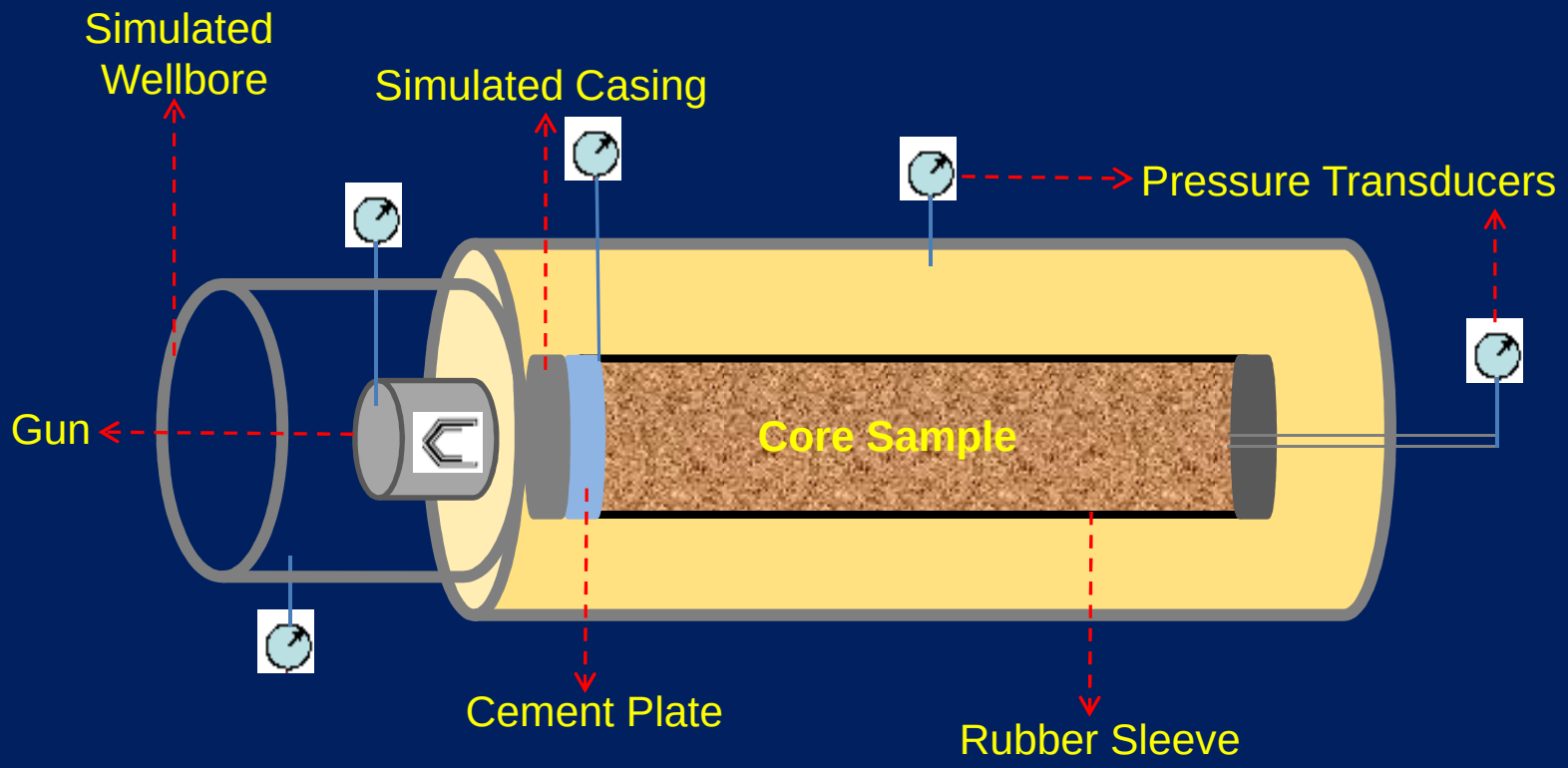
- Improve injectivity and flow performance.
- Enhance stimulation job's efficiency .
- Increase productivity to a point that would offset cost.

SPE116226, SPE122174,
SPE125901, SPE144167, SPE149453

Objectives

- Perforate a set of carbonate cores using conventional and reactive charges.
- Evaluate the geometry of reactive charges in carbonate rocks.
- Evaluate the effect of reactive charges on acid wormholing.

Experimental Procedure and Parameters



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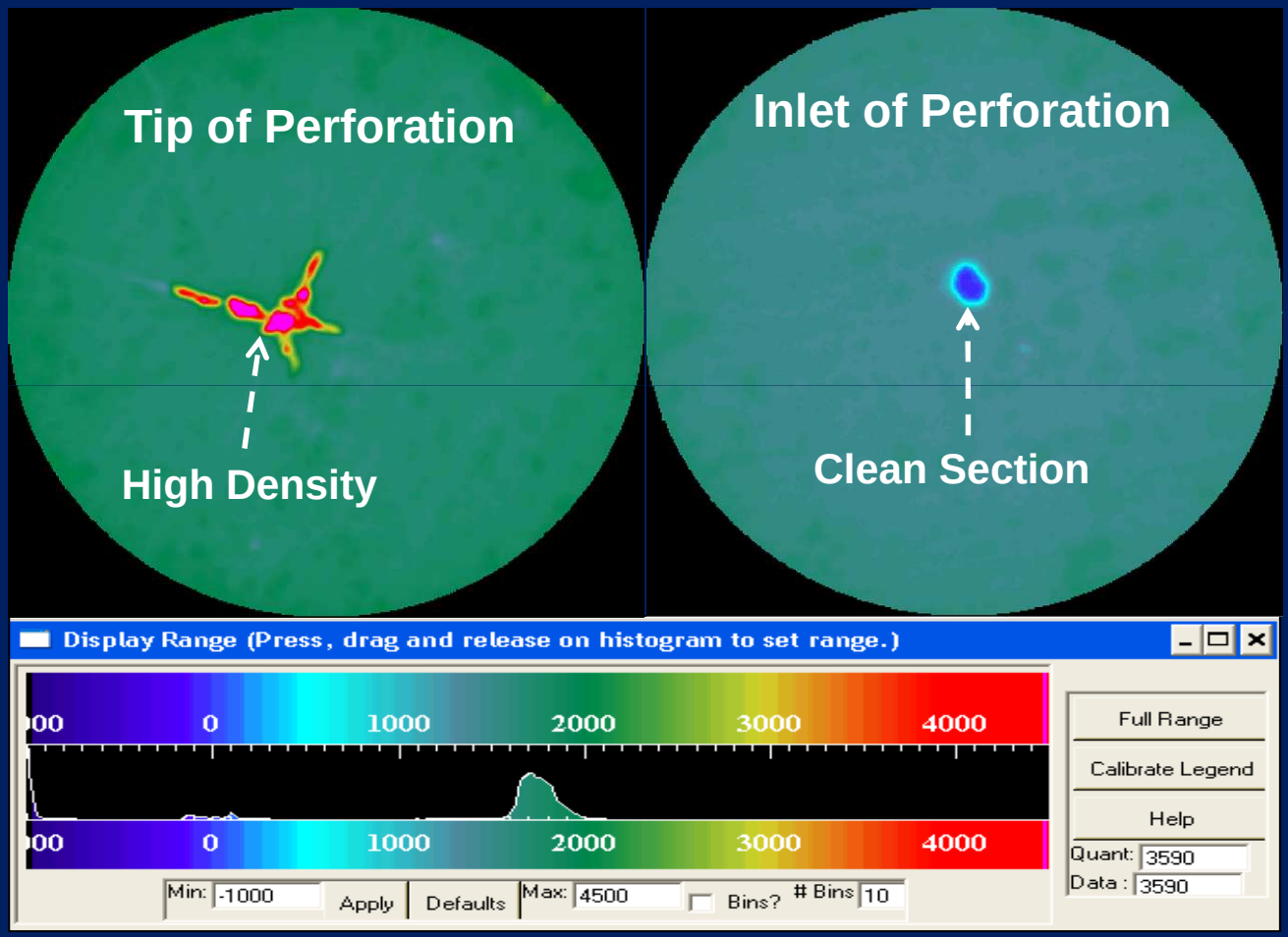

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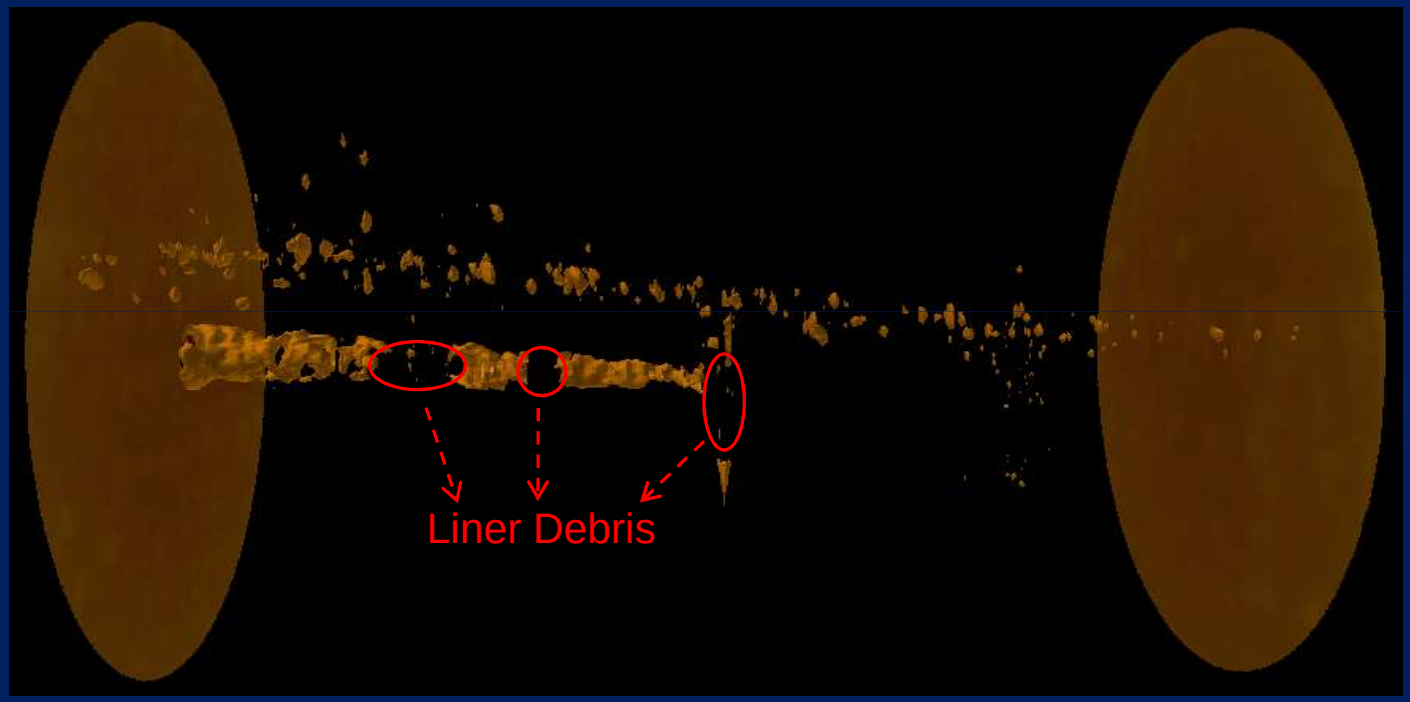

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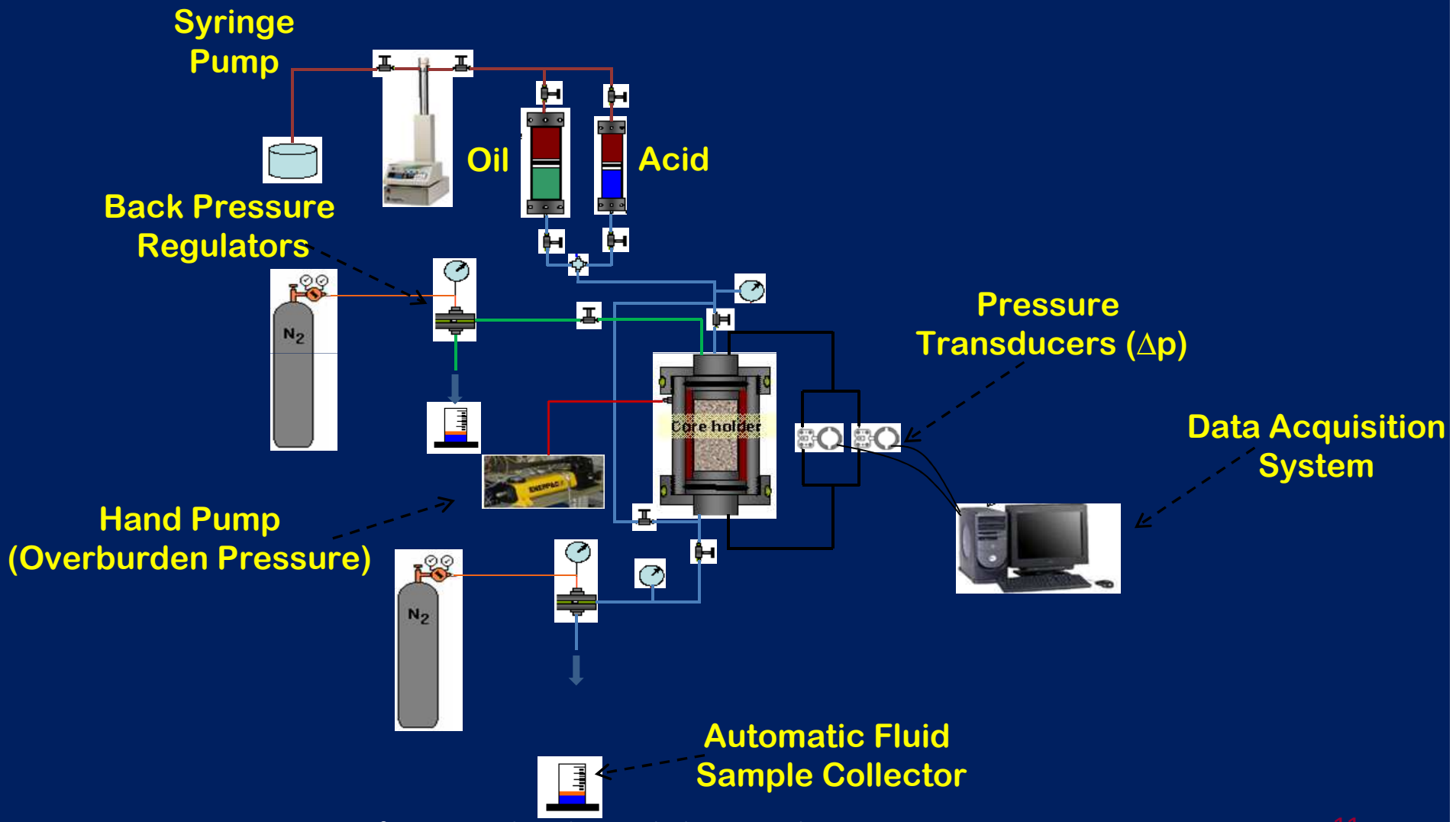

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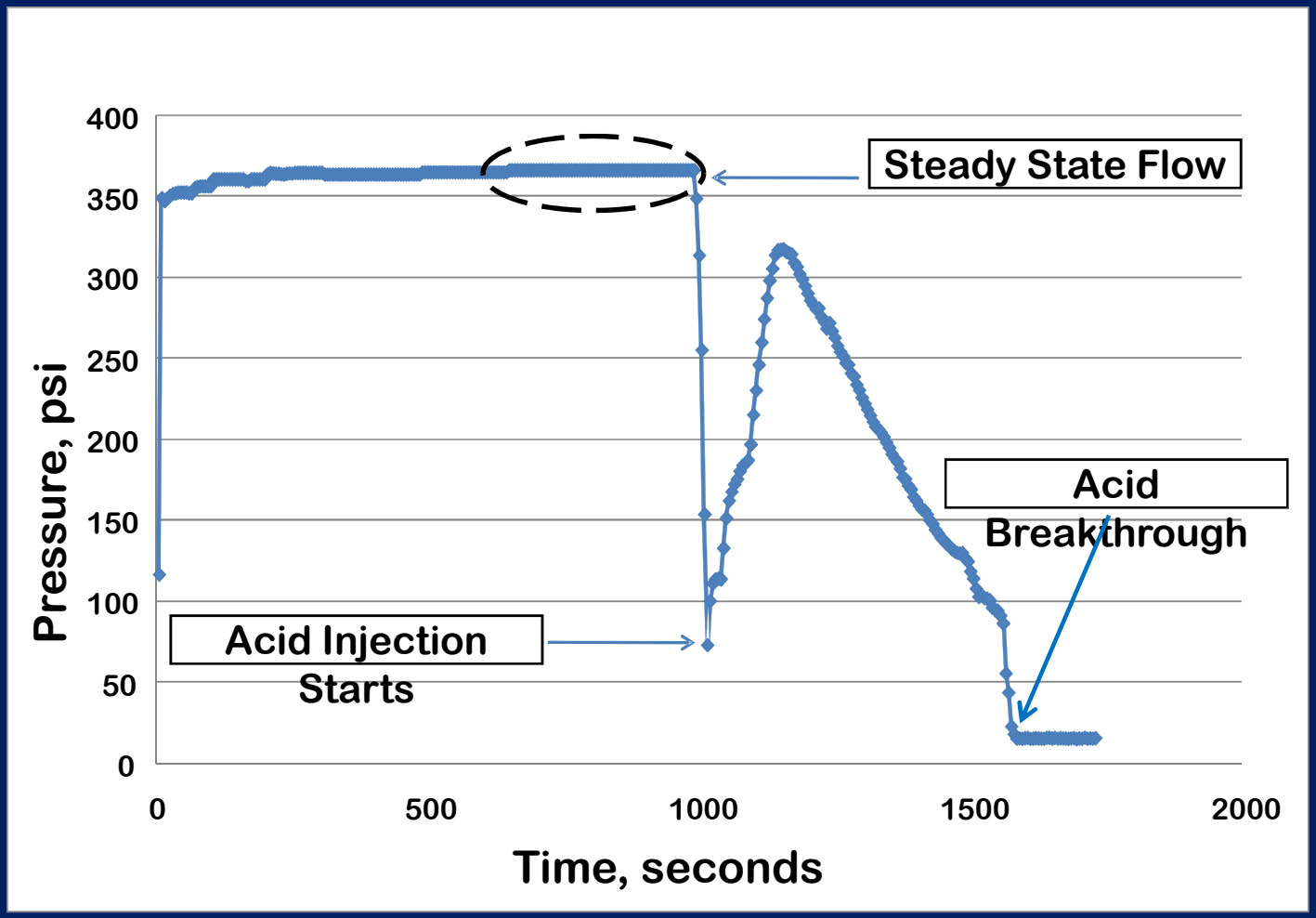
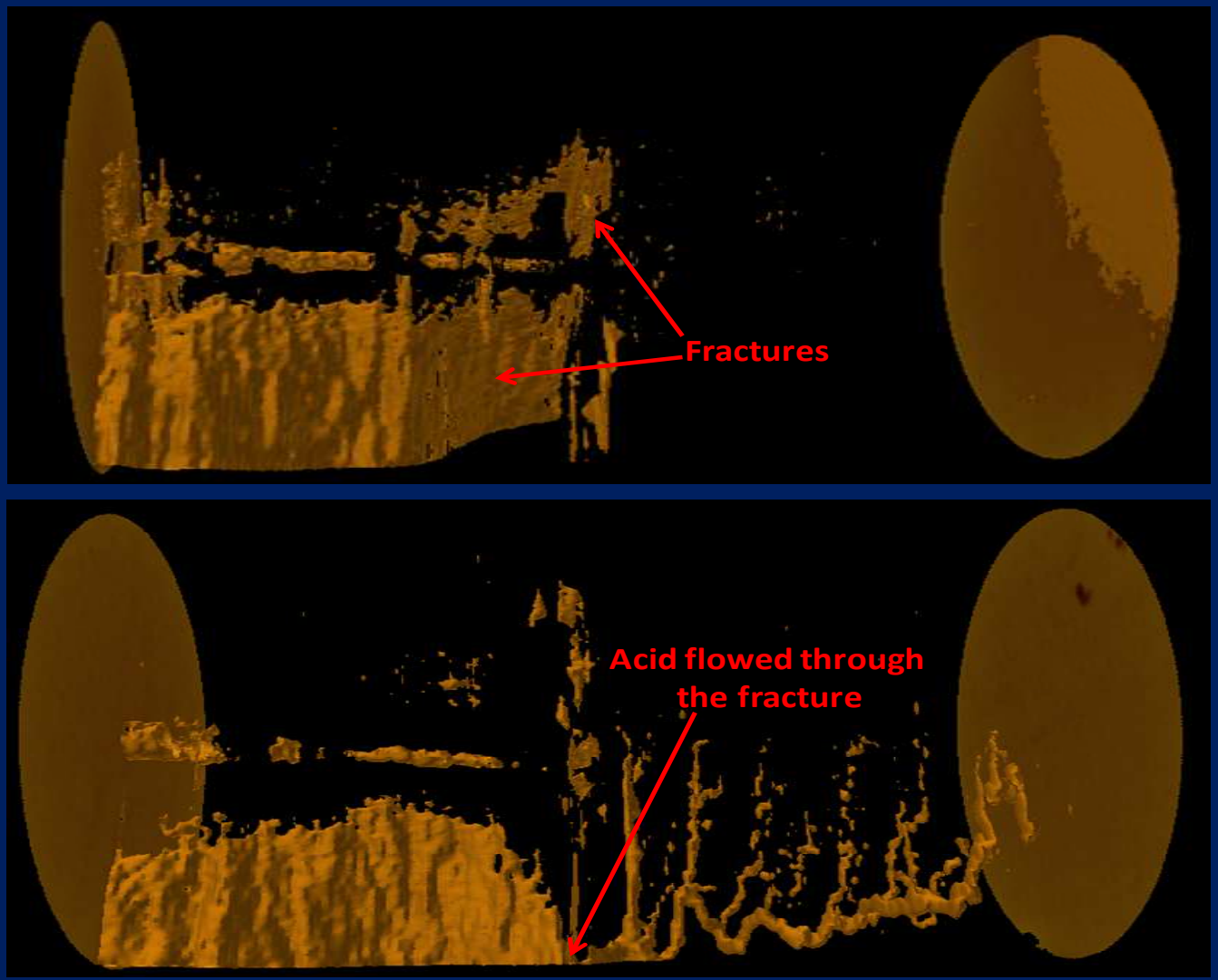


Experimental Procedure and Parameters

Initial Experiments



Initial Experiments Results

15 gram Charges

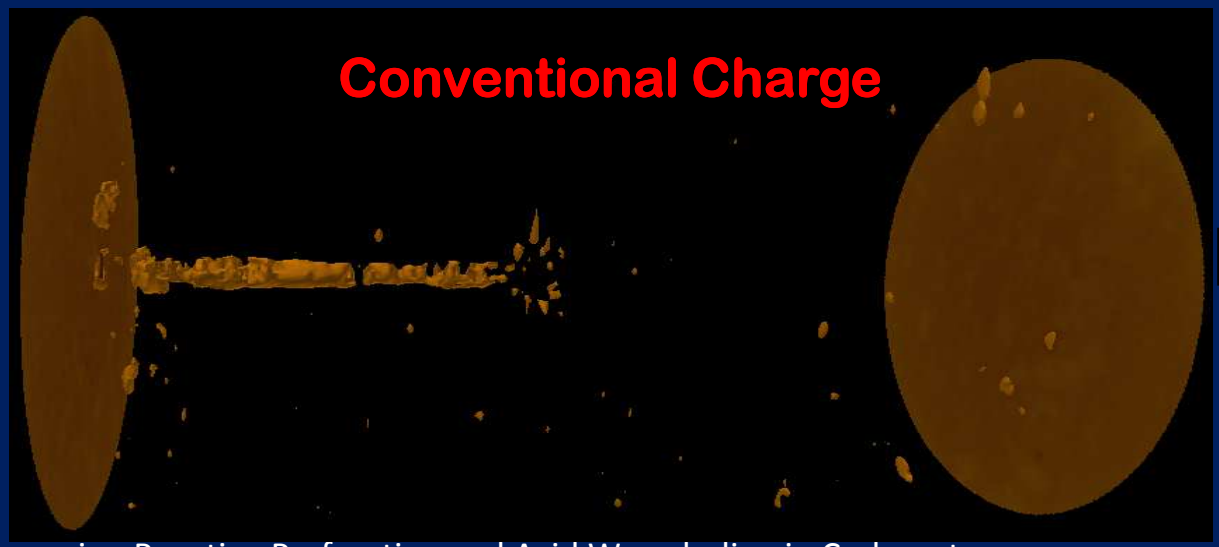
Shot Type	Injection ΔP, psi	Acid to Break through, ml
Conventional	274.00	66.67
Reactive	327.00	58.23
Conventional	321.50	41.67
Reactive	660.00	101.67
Conventional	206.00	62.5

7 gram Charges

Shot Type	Injection ΔP, psi	Acid to Break through, ml
Conventional	406.00	65
Reactive	371.00	60
Conventional	421.00	64.17
Reactive	386.00	73.33
Conventional	953.00	77.5
Reactive	335.00	60.42

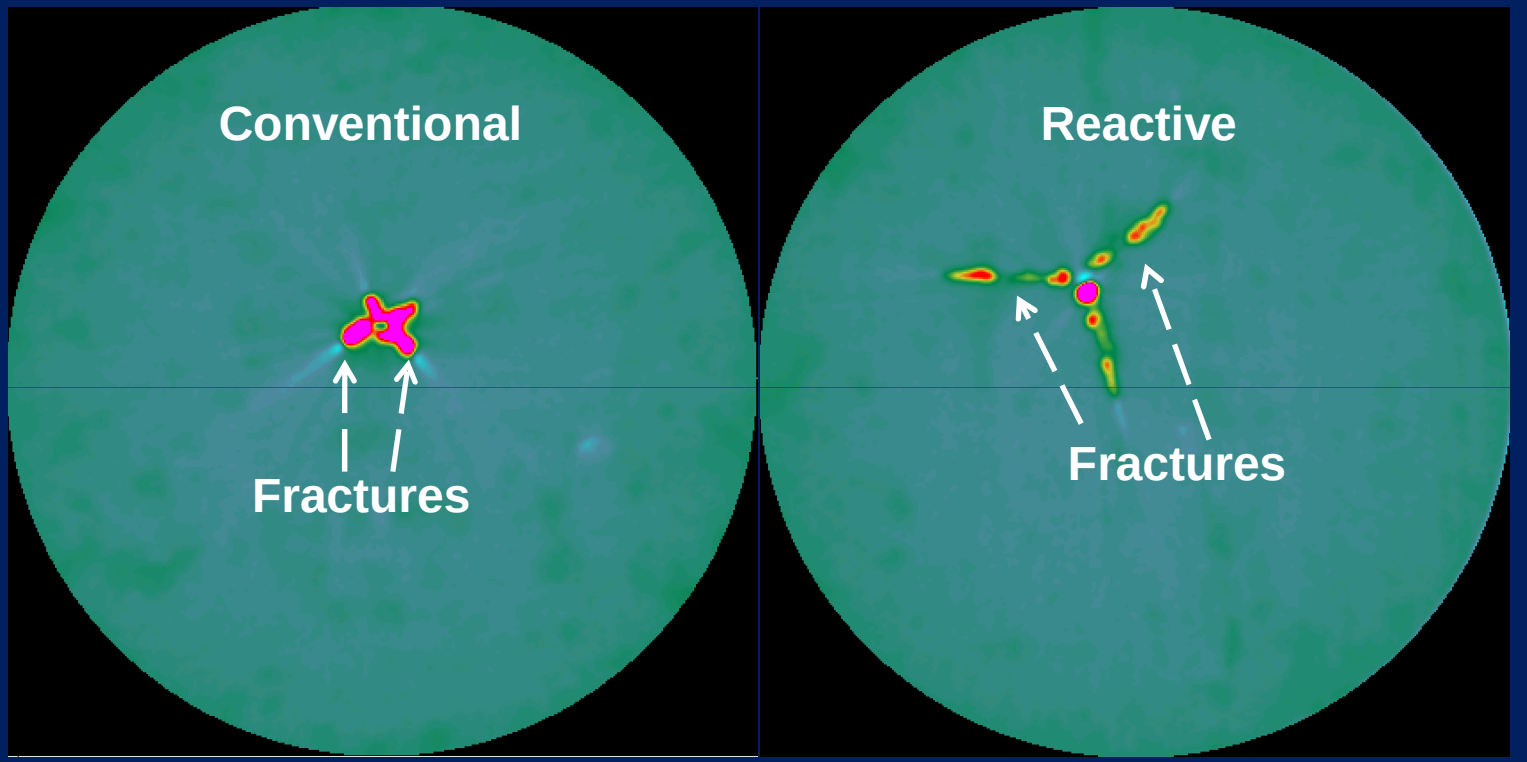
Conventional Vs Reactive Charges

Perf. L = 10.39 in
Perf. D = 0.26 in
K = 3.5 md
ΔP_{inj} = 335 psi



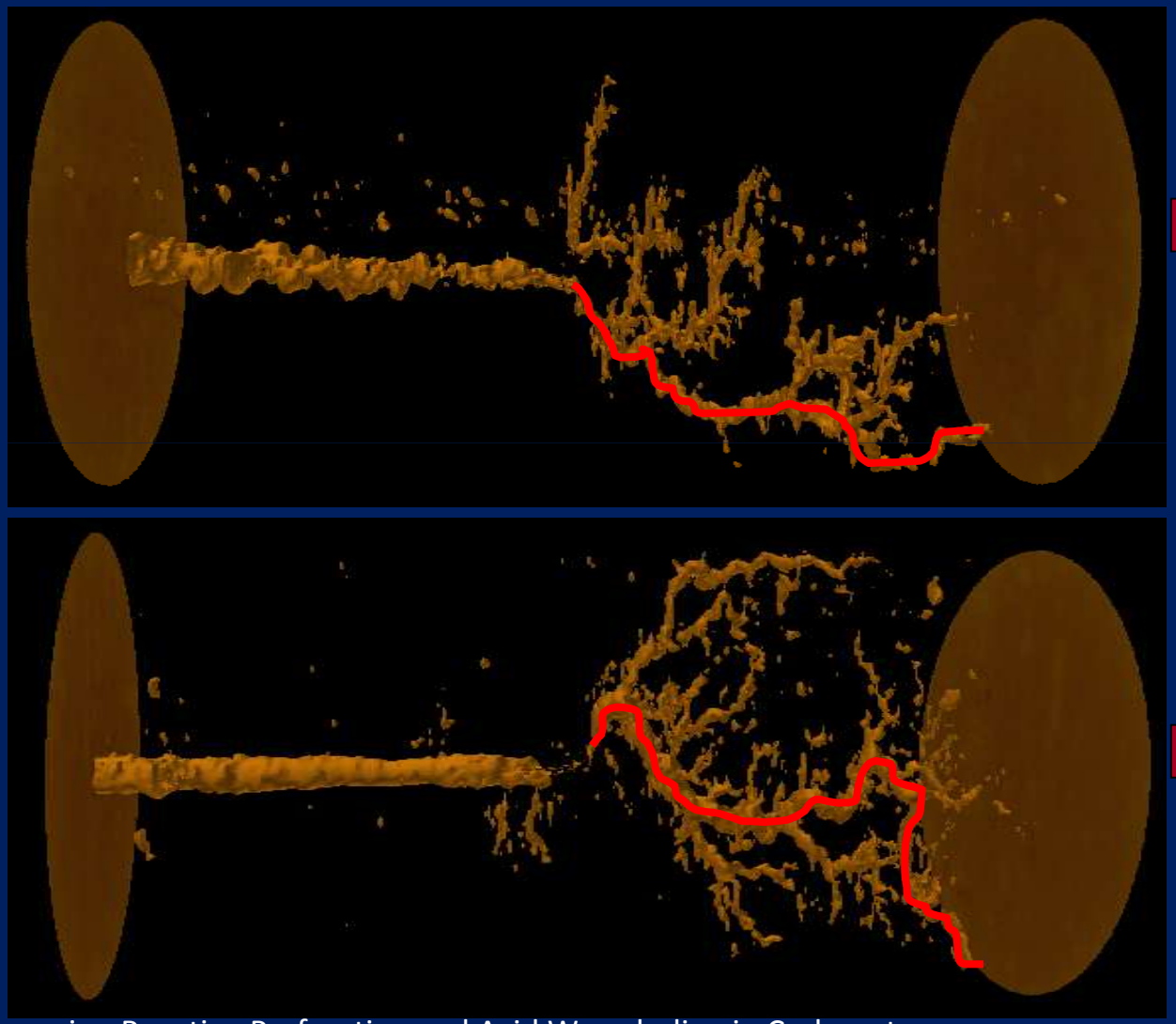
Perf. L = 10.27 in
Perf. D = 0.21 in
K = 5.3 md
ΔP_{inj} = 351 psi

Conventional Vs Reactive Charges



CT images taken at the tip of the perforations before acidizing

Conventional Vs Reactive Charges



Reactive Charge

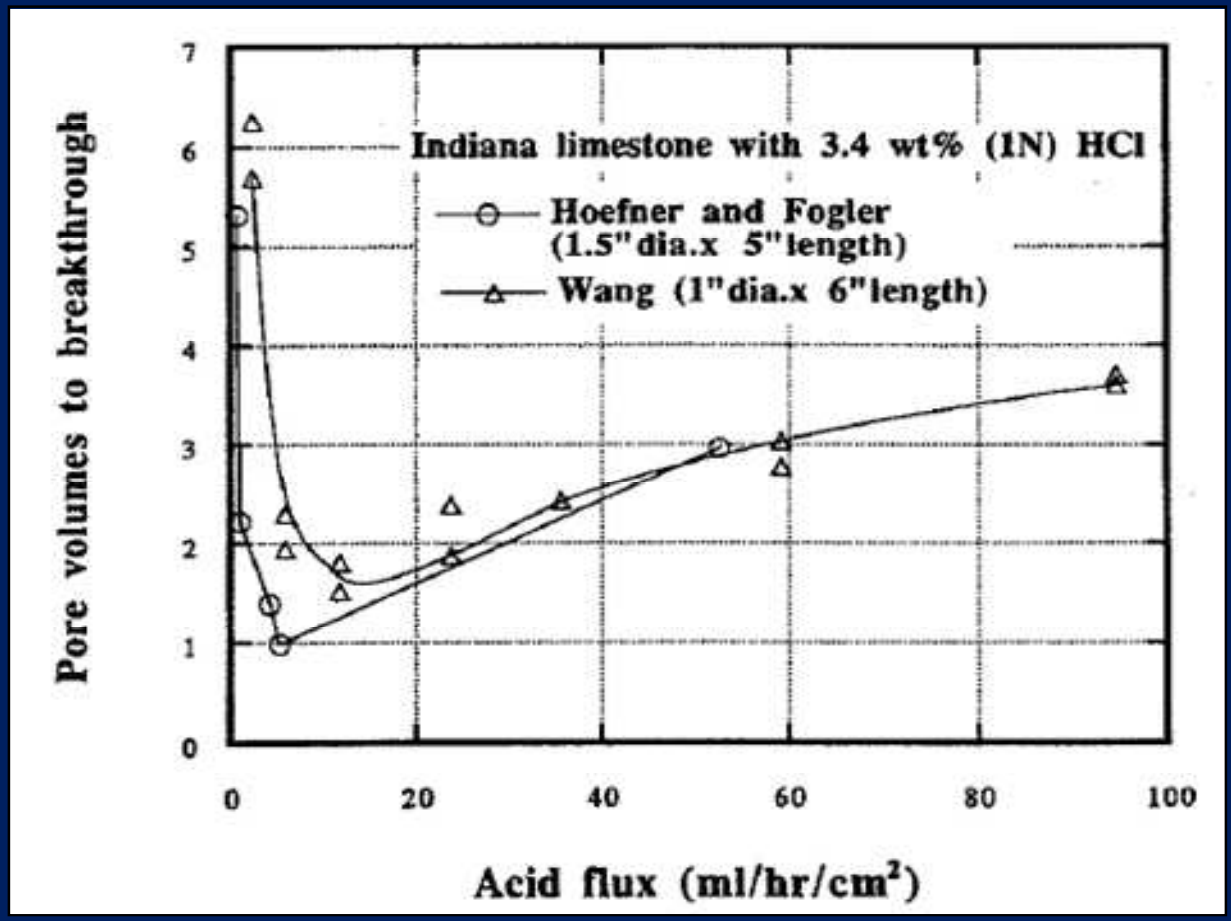
V_{acid} = 91 ml

Conventional Charge

V_{acid} = 95 ml

Acid Flux Effect on Wormholing

Optimum injection rate (Economides et al. 1994)

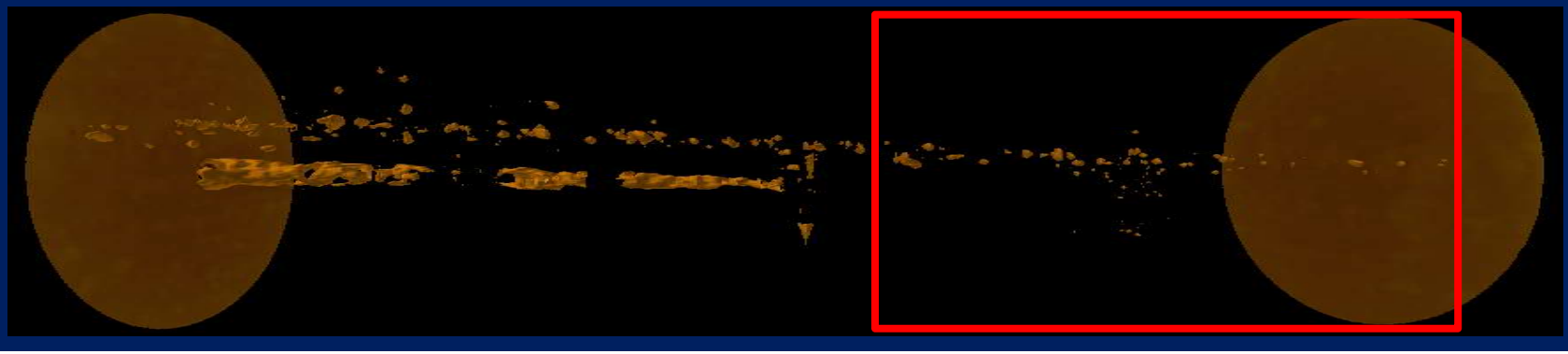


Perforating Results: Tunnel Dimensions

Charge Wt, Grams	Type of Shaped Charge	Perforating Pressure Condition	Inlet Perforation Diameter, inches	Perforation Length, inches	Volume of Perforation, cubic inches
7	Conventional	Balanced	0.206	10.27	0.33
7	Reactive	Balanced	0.257	10.39	0.49
7	Conventional	Overbalanced	0.229	10.27	0.32
7	Reactive	Overbalanced	0.263	10.51	0.50
12	Conventional	Balanced	0.320	17.72	1.09
12	Reactive	Balanced	0.390	15.42	1.05

Acidizing Results: Injectivity and Acid to Breakthrough

Type of Shaped Charge	Porosity, fraction	Original Rock Permeability, md	Injection ΔP, psi	Acid to Break through, ml	Acid to Break through, PV
Conventional	0.257	5.29	375	95	0.1851
Reactive	0.256	3.48	351	91	0.1802
Conventional	0.254	2.67	365	87	0.1712
Reactive	0.256	2.89	298	85	0.1706
Conventional	0.259	3.95	224	56	0.4605
Reactive	0.258	2.58	288	63	0.2589



Conclusions

- CT scan images and effluent fluid samples confirmed the presence of debris.
- Reactive charges tested in this project provide perforation tunnels with higher injectivity.
  - Tunnels with larger diameter.
  - Long fractures at the tip of the tunnels.
- Tunnels created with reactive charges help to generate dominant wormholes.

Path Forward

- Future experiments are planned using larger cores and shaped charges to better simulate field conditions.
- The facilities have been constructed and are in the process of commissioning.

15 KPSI Heated Treatment Cell

Acid and Fluid Injection System

EVALUATION OF PERFORATED CARBONATE CORES UNDER ACID STIMULATION

GEODynamics Reactive Perforating and Acid Wormholing in Carbonates
28-30 November, 2011 Middle East and North Africa Perforating Symposium

References

- **Bartko, K.M., Chang, F.F., Behrmann, L.A., and Walton, I.C**.: "Effective Matrix Acidizing in Carbonate Reservoir-Does Perforating Matter?", SPE 105022, 15th SPE Middle East Oil and Gas Show, Bahrain, 11-14 Mar 2007.
- **Bell, M.R.G., Hardesty, J.T., Clark, N.G.**: "Reactive Perforating: Conventional and Unconventional Applications, Learnings and Opportunities", SPE 122174, SPE European Formation Damage Conference, Netherlands, 27-29 May 2009.
- **Behrmann, L.A., Hughes, K., Johnson A.B. and Walton, I.C.**: "New Underbalanced Perforating Technique Increases Completion Efficiency and Eliminates Costly Acid Stimulation", SPE 77364, SPE Annual Technical Conference and Exhibition, Texas, 29 September-2 October 2002.
- **Lloyd Stutz, H., Behrmann, Larry A**., "Dynamic Under Balance Perforating Eliminates Near Wellbore Acid Stimulation in Low-Pressure Weber Formation", SPE 86543, SPE International Symposium and Exhibition on Formation Damage Control held in Lafayette, Lousiana,18-20 February 2004.
- **Cocanower, R.D**., "Perforating Assumes New and Greater Importance in Well Stimulation", SPE 799, Mechanical Engineering Aspects of Drilling Production Symposium in Fort Worth, Texas, 23-24 March 1964.
- **Williams, Bert B., Gidley, John L., and Schechter, Robert S**., "Acidizing Fundamentals ", Jun 1979.
- **Economides, Michael J., Hill, Daniel A., and Economides, Christine E**., "Petroleum Production Systems", December 1993.

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