Uso de Agentes de Sostén Ultra-Livianos en Reservorios Tight Gas

Jornadas de Evaluación y Desarrollo de Reservorios Tight

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Alberto Castro

BJ Services Company

Outline

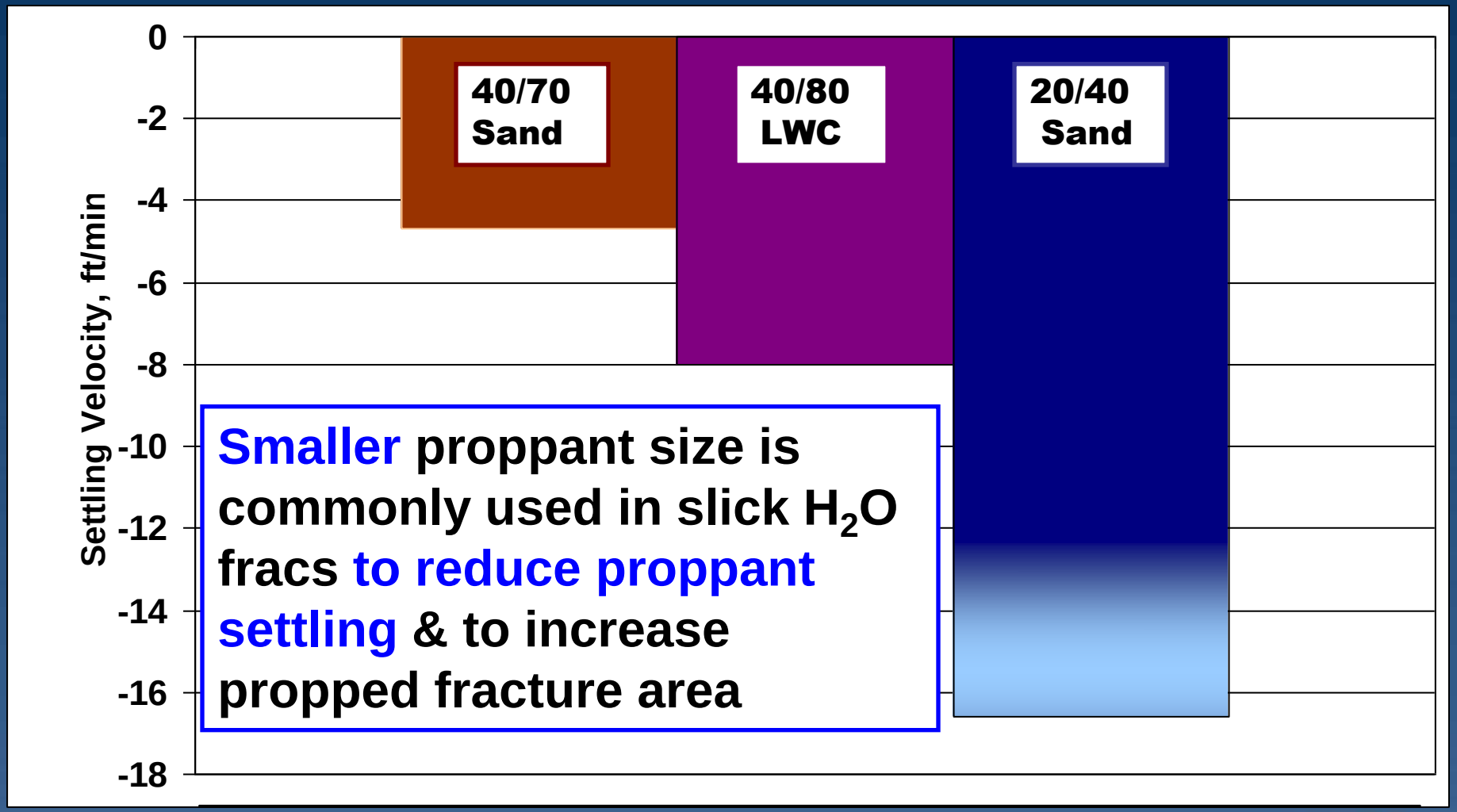
- Introduction
- Proppant Settling
- Proppant Transport & Placement in Slickwater
  - Sand @ low concentration
  - Ultra-lightweight proppant in partial monolayers (PML's)
- Effects on Stimulated Well Productivity
- Return On Fracturing Investment
- PML Case Histories
- Conclusions

Introduction

- Development of sub-millidarcy permeability reservoirs has given rise to the widespread application of slickwater fluids.
  - + Economical, low polymer content 'non-damaging' fluid
  - − Poor fluid efficiency, & poor proppant transport capability
- Effective fracturing of low permeability reservoirs requires effective placement proppant across a large fracture area to promote productive stimulation.
- Poor transport of slickwater fluids may be mitigated by:
  - Higher pump rate - Completion limitations, increased cost
  - Smaller proppant size - Significant conductivity loss
  - Lower density proppant - BHST / Stress limitations, increased cost

Proppant Settling

Various Sizes of Proppants in Water



mFrac Design Model Information

Reservoir Properties & Treatment Parameters

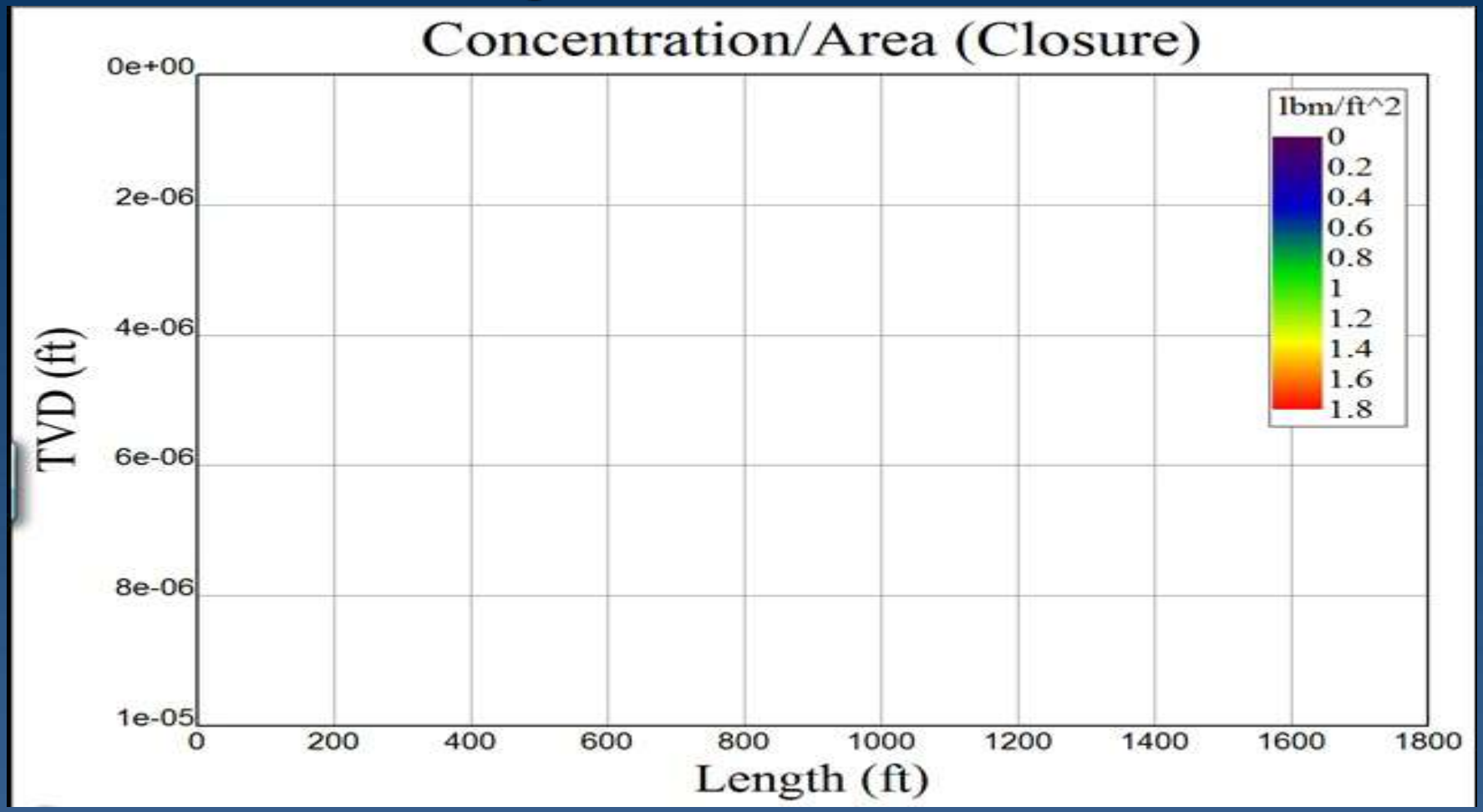
Tight sand -	Dry gas	Treating Rate -	80 BPM
Depth -	7,300-7,600 ft	Fluid -	Slickwater, 3 cP
Porosity / Perm. -	7% / 0.001 mD	Leakoff Coef. -	0.001
Youngs Modulus -	2.0 X E6	Stress Gradient -	0.9 psi/ft
BH Pressure -	4,500 psi		

Frac Treatment Fluid & Proppant Volume

- Frac-A 300,000 lb 40/70 sand, 208 Mgal Slick H_2O
- Frac-B 38,500 lb 14/40 ULW-1.05, 221 Mgal Slick H_2O
- Frac-C 19,500 lb 40/100 ULW-1.05, 196 Mgal Slick H_2O

Frac A - 300 Mlb of 40/70 Sand

208 Mgal Slickwater @ 80 BPM



Created Area - 820,000 ft^2 **Effective Area – 24 %** **Avg. Conductivity - 173 md-ft**

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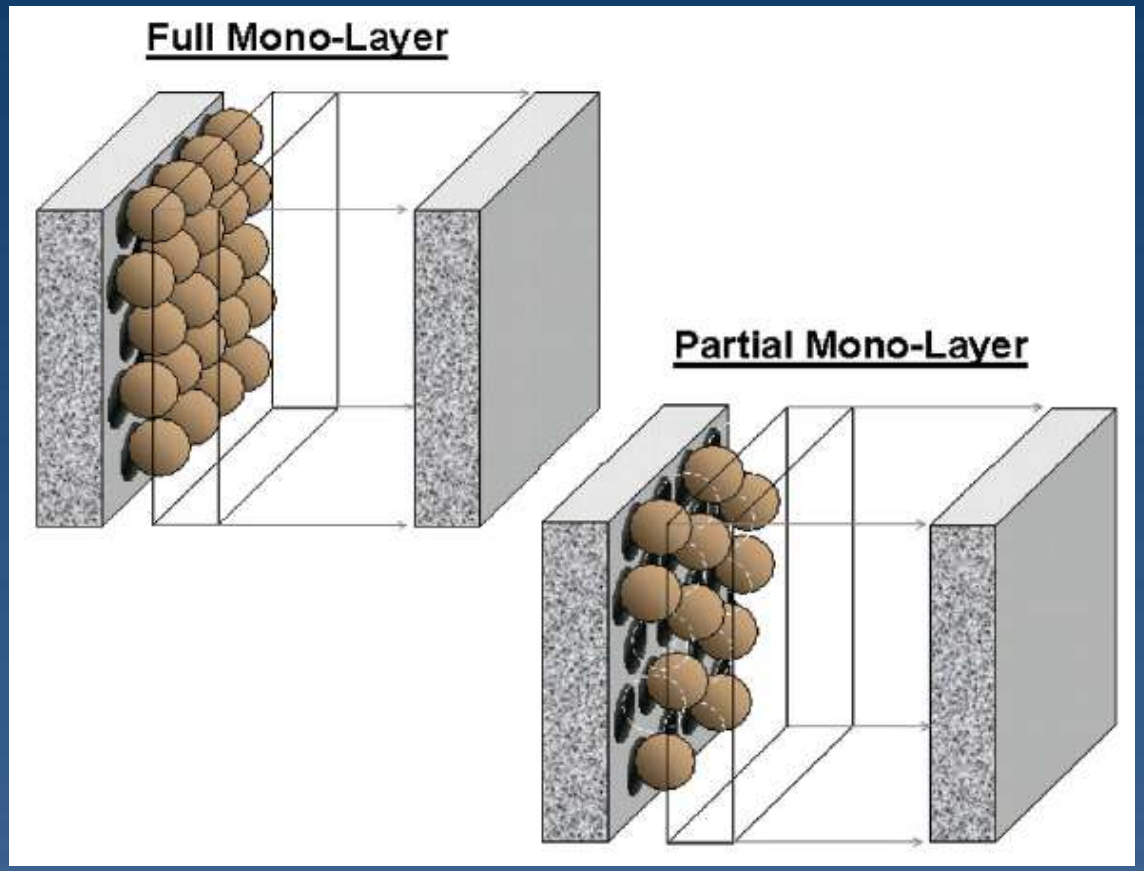
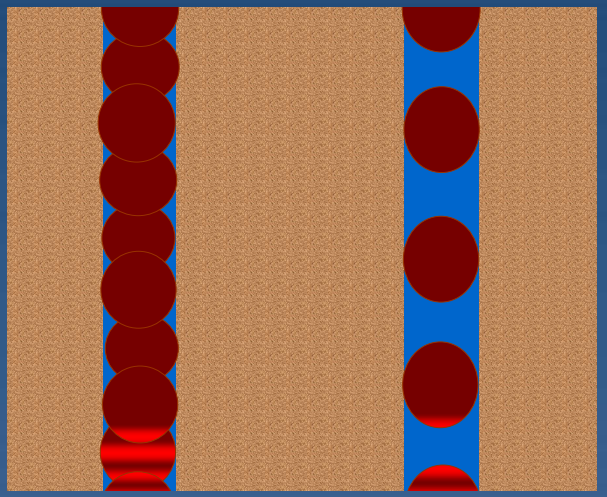
Proppant Partial Monolayers

And Old, but reengineered technique



Proppant PML's exhibit vacant areas around and between particles providing increased conductivity of the propped fracture



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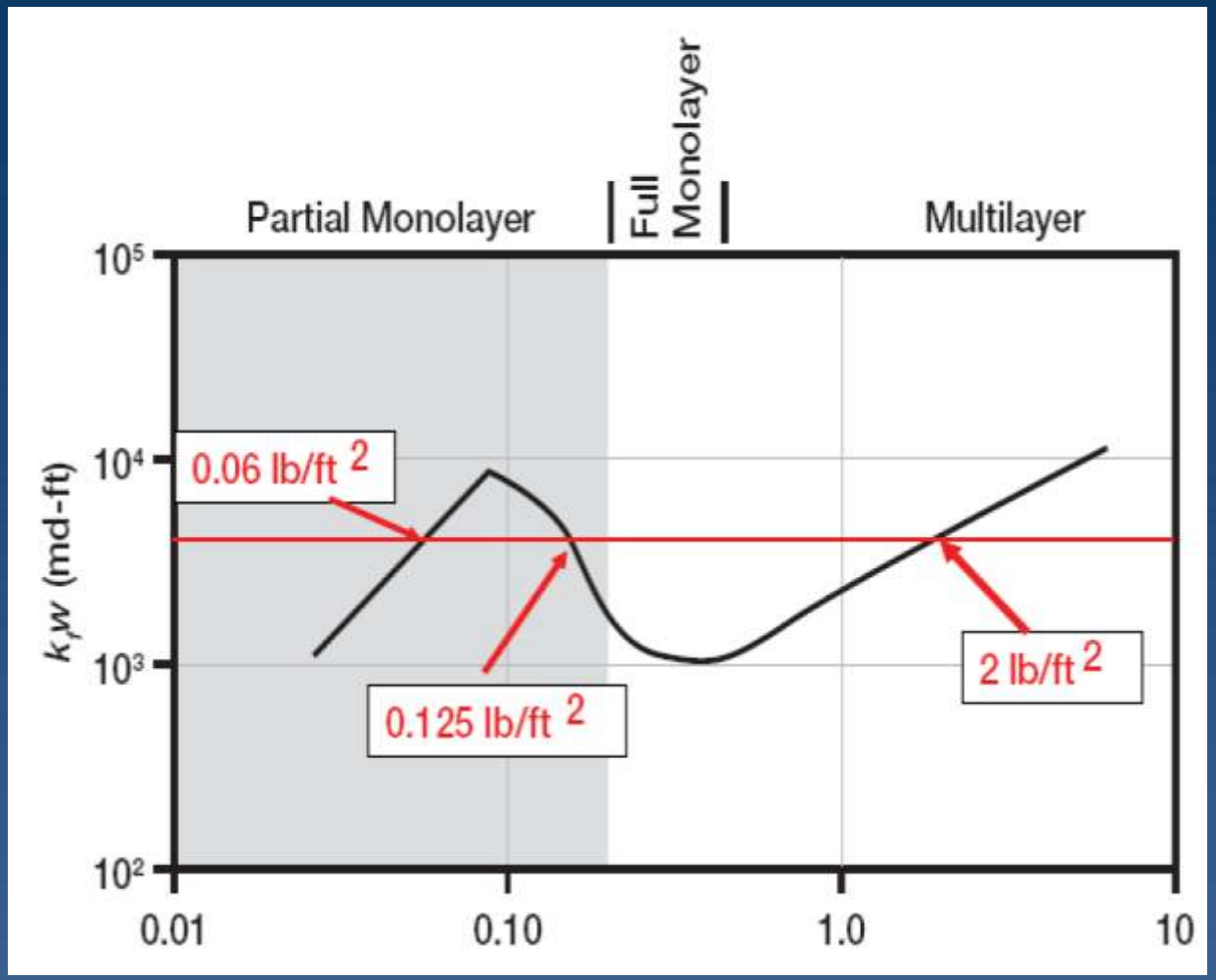
Sand 20/40

Conductivity vs Concentration



At low temperature and closure stress (from Darin & Huitt, 1965)

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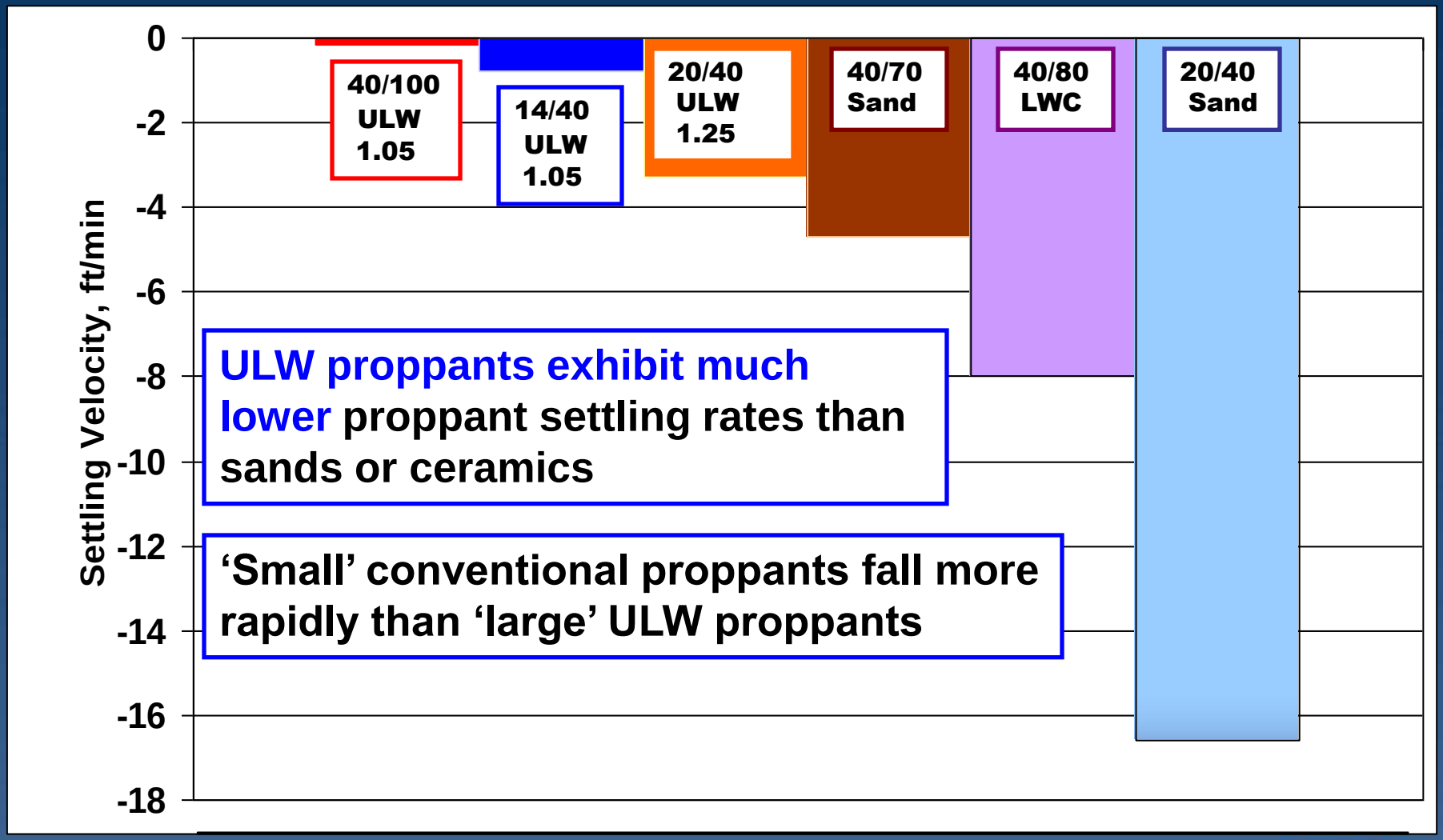
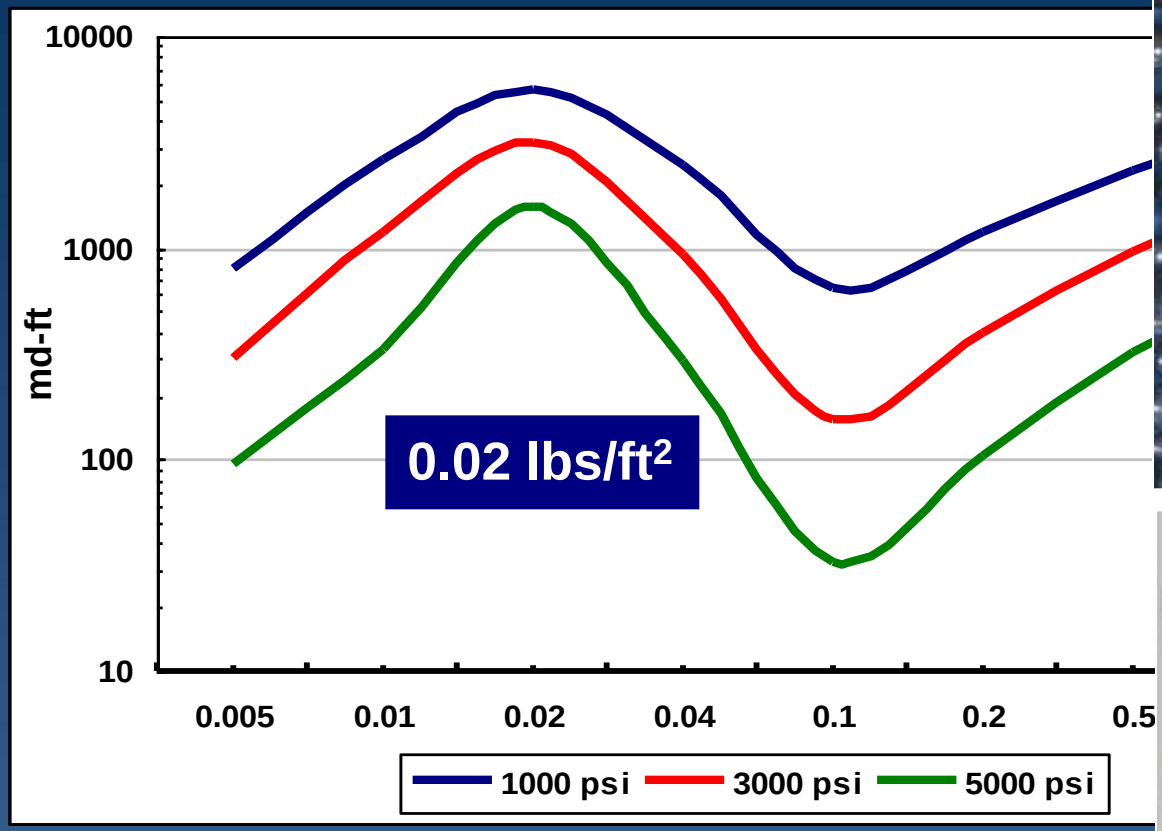
Proppant Settling

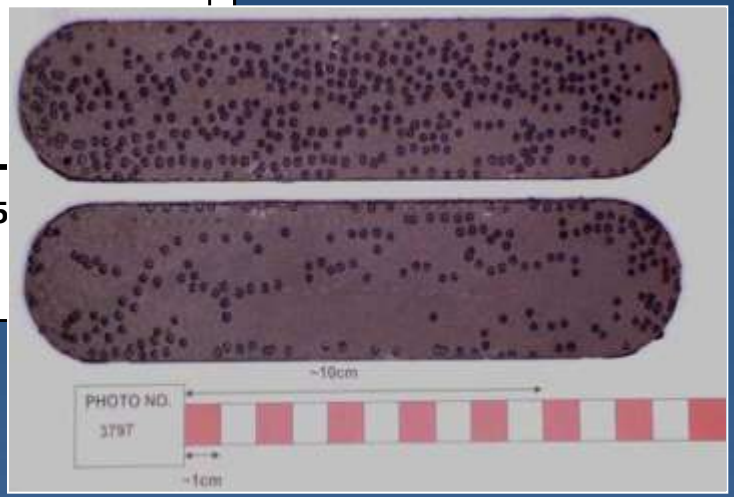
Various Sizes of Proppants in Water



ULW-1.05 Proppant, 14/40

Conductivity vs Concentration @ 150°F





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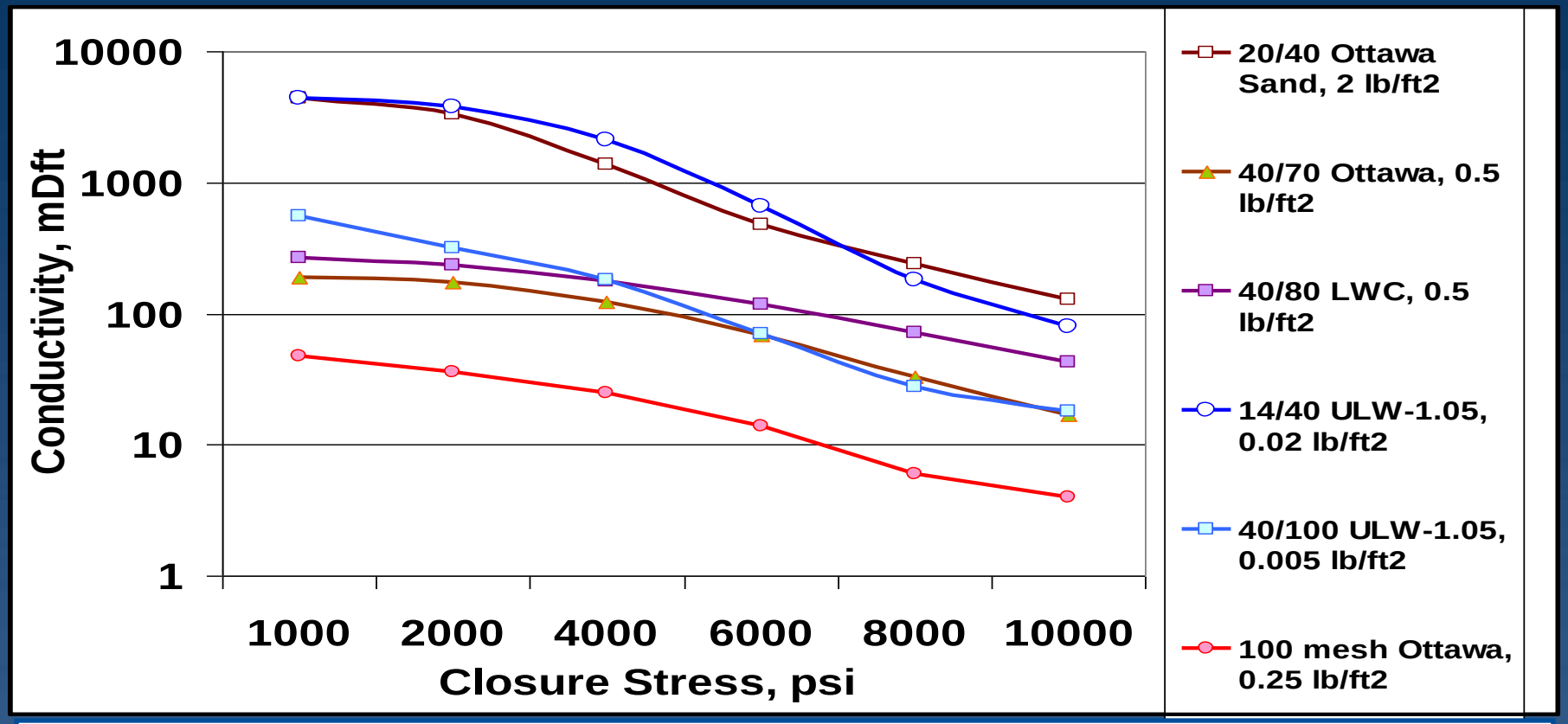
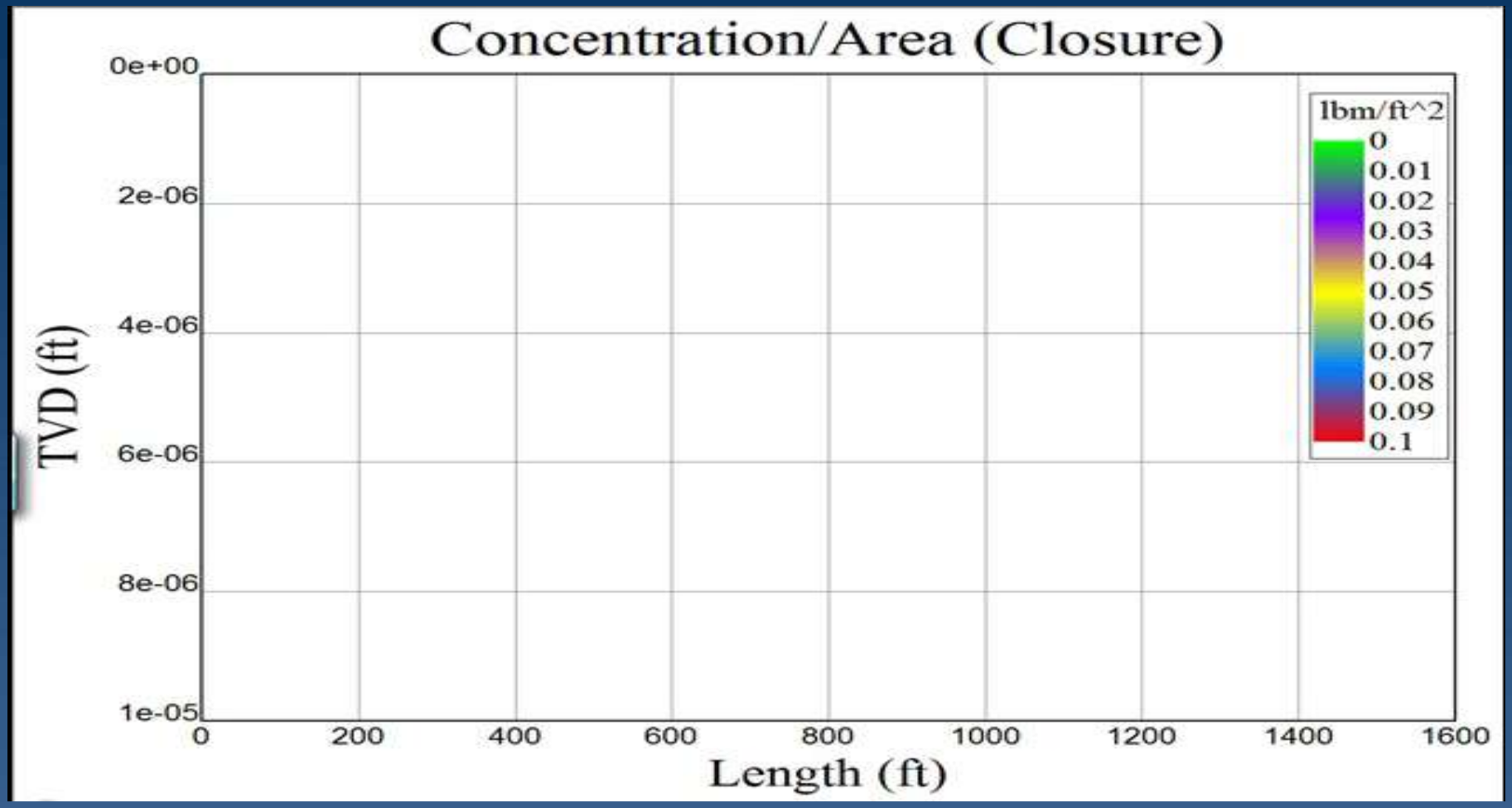
Baseline Fracture Conductivity of Various Proppant Types, Sizes, and Concentrations



Ultra-lightweight proppant partial monolayers provide baseline fracture conductivities comparable or better than multilayer packs of conventional proppants of similar mesh size.

Frac B – ULW Proppant Partial Monolayer

38.5 Mlb 14/40 ULW-1.05, 221 Mgal Slickwater @ 80 BPM



Created Area - 820,000 ft² **Effective Area – 92%** **Avg. Conductivity - 294 md-ft**

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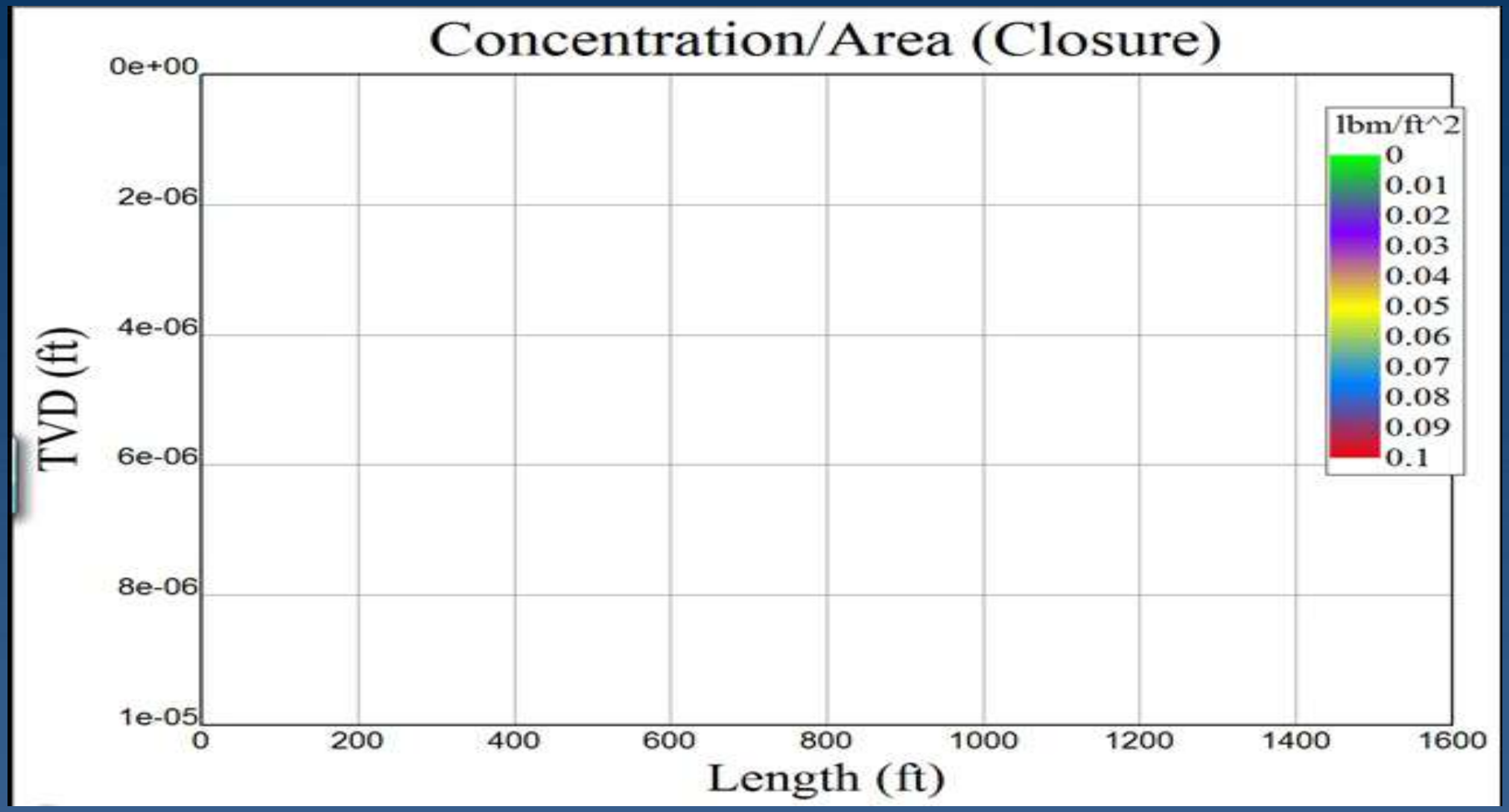
Frac C - ULW Proppant Partial Monolayer

19.5 Mlb 40/100 ULW-1.05, 196 Mgal Slickwater @ 80 BPM



Created Area - 786,000 ft² **Effective Area - 94%** **Avg. Conductivity - 48 md-ft**

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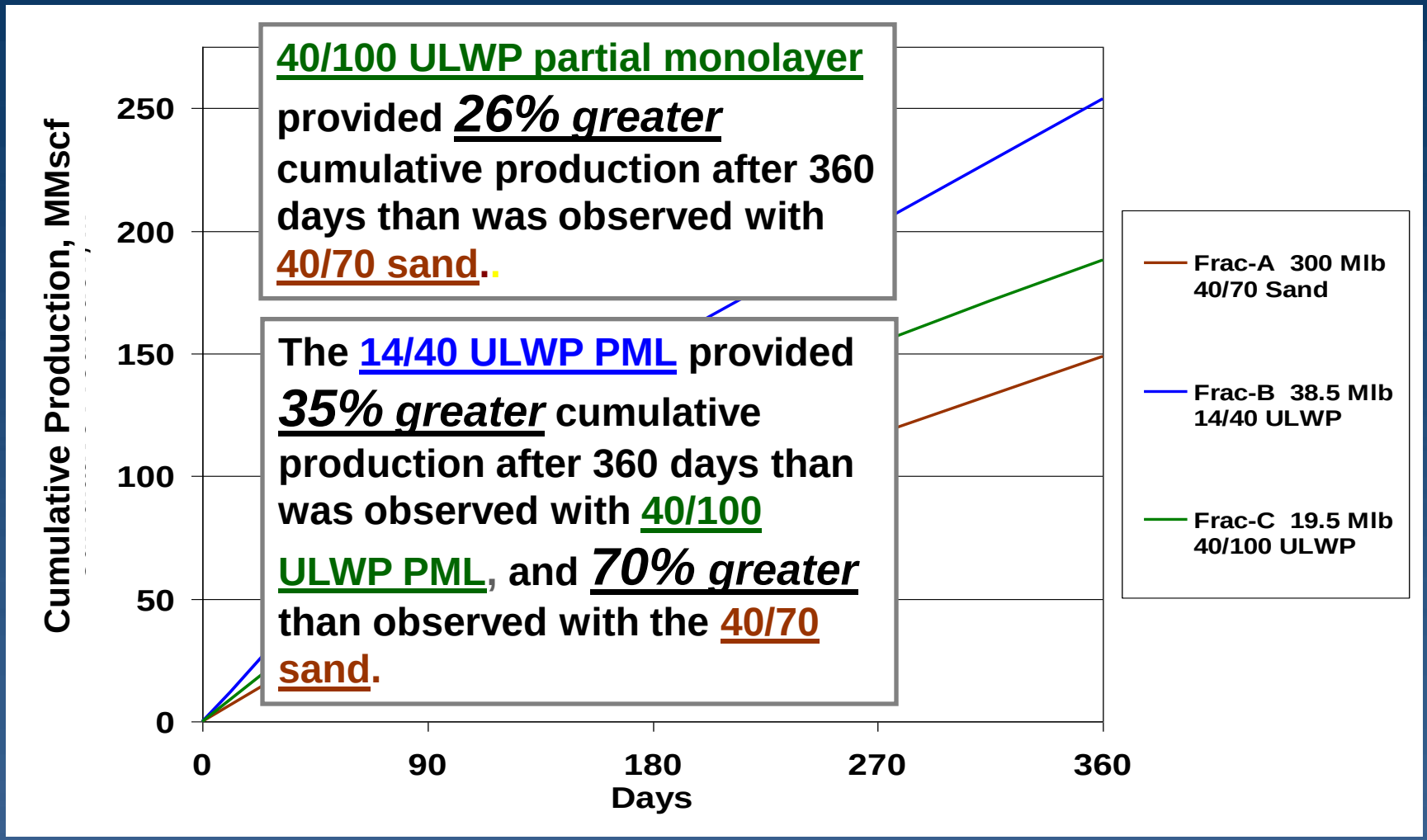
Slickwater Frac Cumulative Production

Comparison of Conventional Sand Pack & ULW Proppant Partial Monolayer



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Frac Data / Well Performance

	Created Frac Area, ft^2	Effective Frac Area, %	Fracture Conductivity, mD-ft	Cumulative Production, 360 days, Mscf
Frac-A 40/70 Sand	820,000	24 %	173	149,000
Frac-B 14/40 ULW-1.05 PML	820,000	91 %	294	254,000
Frac-C 40/100 ULW-1.05 PML	786,000	97 %	48	188,000

Created fracture area is a function of the slurry volume pumped and for this study, both slurry volume and created area were similar for all examples

Effective Frac Area of frac with 300 Mlb of conventional proppant was 24%, compared to greater than 90% for partial monolayers of ULW-1.05 proppant

Fracture conductivity of the treatment using sand was relatively 'higher' due to the proppant settling into dunes having concentrations up to 3 lb/ft^2.

Production performance was observed to correlate more strongly with the Effective Frac Area than with the Created Frac Area or Fracture Conductivity

Frac Treatment Economics

	Prop Mlb / ft^3	Prop \$/ft^3	Proppant Cost, \$	Fracturing Treatment Cost, \$
Frac-A 40/70 Sand	300 / 3,000	\$ 30	\$ 90,000	\$ 286,400
Frac-B 14/40 ULW-1.05 PML	38.5 / 939	\$ 166	\$ 155,878	\$ 336,528
Frac-C 40/100 ULW-1.05 PML	19.5 / 476	\$ 166	\$ 78,951	\$ 237,701

The fracturing treatment costs were calculated by adding \$ 0.8/gal of fluid pumped and \$ 0.1/lb of proppant to the proppant costs.

The higher unit costs of ULW proppants vs. sand were observed to be offset in evaluation of treatment costs by the substantially reduced ULW-1.05 proppant volumes (8 – 15 times fewer pounds) used to place PML´s

The 40/100 ULW-1.05 partial monolayer treatment exhibited the lowest cost, primarily due to using the least amount of proppant.

Return On Fracturing Investment

	Frac Treatment Cost, $	Cum. Production Value, 360 Days @ $4 per Mscf	ROFI, $ in 360 days	ROFI, % in 360 days
Frac-A 40/70 Sand	$ 286,400	$ 596,000	$ 309,600	108 %
Frac-B 14/40 ULW-1.05 PML	$ 336,528	$ 1,016,000	$ 679,472	202 %
Frac-C 40/100 ULW-1.05 PML	$ 237,701	$ 752,000	$ 514.299	216 %

The ULW-1.05 PML fracs were observed to provide the most favorable 360 day ROFIs. The ROFIs of the ULW-1.05 PML fracs were 2 times higher than the sand frac.

These results are believed to be a consequence of the ULW-1.05 proppant improving transport capabilities and the enabling of conductive partial monolayer placement.

Other Advantages of Using ULW Proppants

- In slickwater fracs: Replacement of sand with equivalent volume of ULW proppant (higher propped area).
- In crosslinked water fracs: Replacement of fluid with slickwater and proppant with ULW, will achieve deeper frac lengths for equivalent proppant volume.
- Allows the use of Ultra high quality foams as frac fluid.

Case Histories

Partial Monolayer Fracs

- SPE 90838: Ultra Lightweight Proppants: their Use and Application in the Barnett Shale
- SPE 91469: Field Application of New Lightweight Proppant in Appalachian Tight Gas Sandstones
- SPE 97998: The Effect of Using a Lightweight Proppant in Treatment of a Low-Permeability, Dry-Gas Reservoir: A case Study
- SPE 98006: Ultralightweight Proppants- A Field Study in the Big Sandy Field of Eastern Kentucky
- SPE 107184: Past Technologies Emerge Due to Lightweight Proppant Technology - Case Histories Applied on Mature Fields

Case History

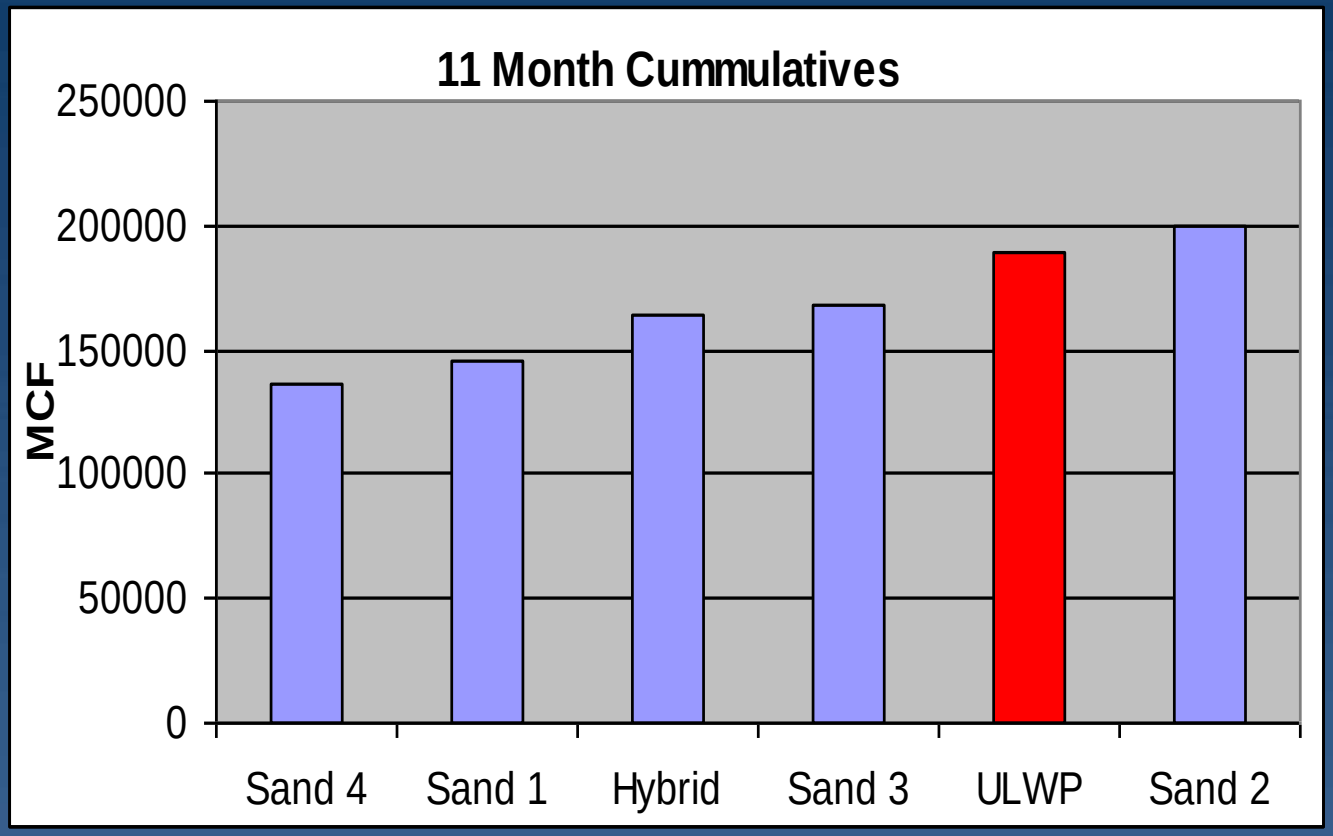
Mesaverde Fm, New Mexico

- Low permeability gas sandstone
- Naturally fractured
- Typical thickness: 900 ft
- Pressure depleted
- Frac Gradient: 0.43 – 0.45

	Sand Jobs	Hybrid	ULWP 1.25
Top Perf	5,360’	5,335’	5,489’
Feet Perfed	319’	329’	323’
Avg. Rate	88 bpm	80 bpm	92 bpm
Avg. Pressure	2,985 psi	3,200 psi	2,959 psi
Gal. Of Fluid	69,855	100,242	97,062
Lbs. of Prop	81,158	35,687	10,050
Lbs./ft-perfed	254	144	67

Case History

Cumulative Production



- ULWP cumulative exceeds production of each of the test wells by as much as 14%, less Sand 2.
- Sand 2 was allowed to be brought on at a rate of 825 mcfd. But declined rapidly.
- Others were chocked back to a 600 mcfd max. rate.

Conclusions

- Slickwater treatments using conventional proppants are subject to significant proppant settling and less than desirable propped fracture area for effective stimulation.
- ULW proppants exhibited significantly better proppant placement characteristics than sand (or ceramic) proppants, providing as much as 4 times greater effective fracture area.
- Production performance correlated more strongly with the Effective Frac Area (area propped) than with the Created Frac Area or Fracture Conductivity.

Conclusions

- The significantly reduced ULW proppant volumes needed for PML concentrations (10 - 20X lower) have been shown to substantially offset the relatively higher unit costs of ULW proppants versus conventional proppants.

- The ultra-lightweight proppant partial monolayer treatments significantly outperformed the conventional proppant / slickwater treatments.
  - The ULW proppant PML fracs exhibited ~ 50% greater productivity than those treated with slickwater and conventional proppants.

Conclusions

- The ultra-lightweight proppant partial monolayer fracturing treatments provided significantly **better Return-On-Fracturing-Investment** than slickwater fracs with sand (or ceramic proppants).
  - 360 day ROFIs for ULW proppant PML **fracs were 2 times greater** than those observed for 40/70 sand.

- **Field results** of proppant partial monolayer fracturing treatments using ULW proppants effectively validate the process.

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Thank You !

Alberto Castro