Fracturing with Light-Weight Proppants

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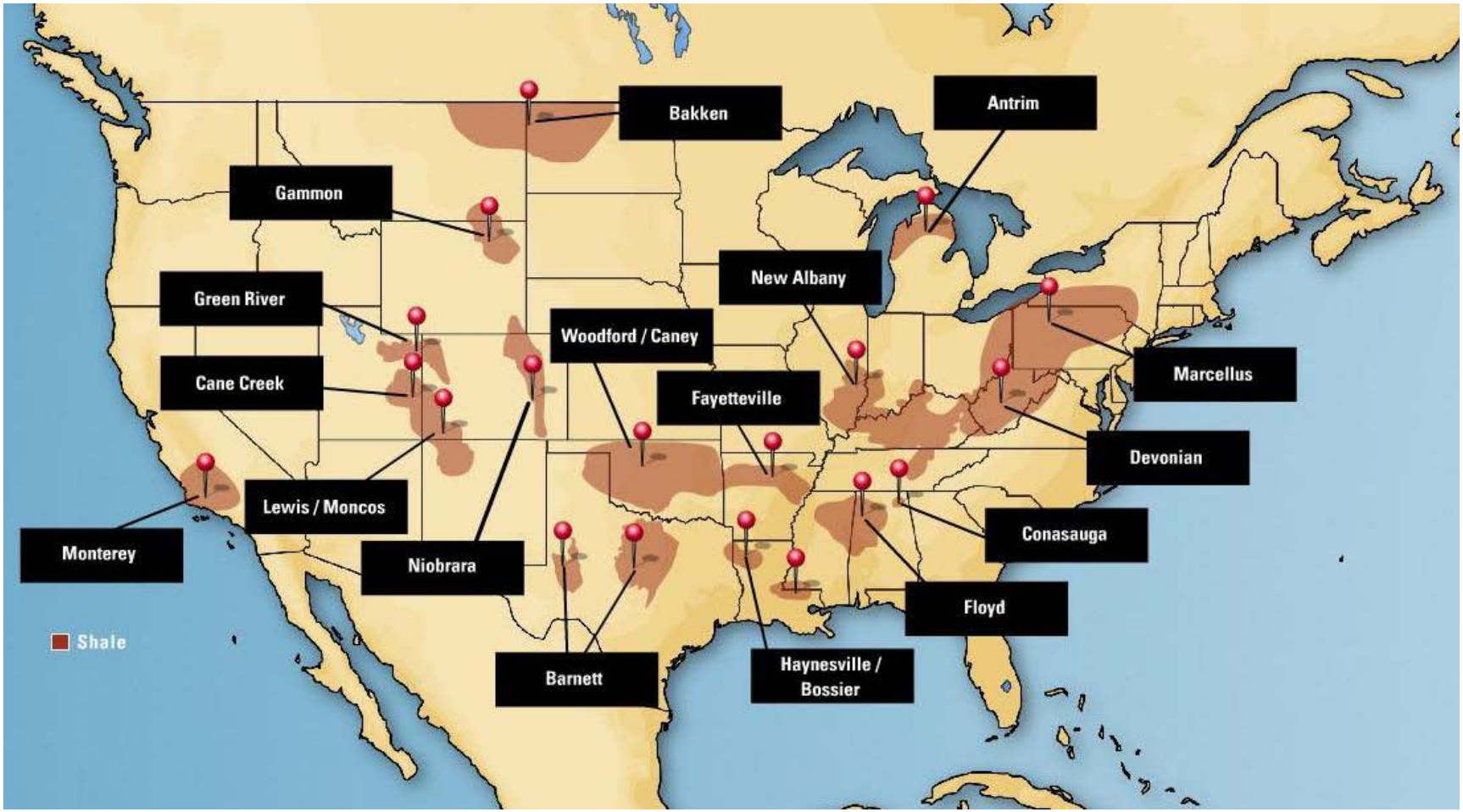
Outline

- Why shale gas?
- Technical issues with fracturing shale gas
- Project Objective
- Project Tasks
- Results
- Conclusions

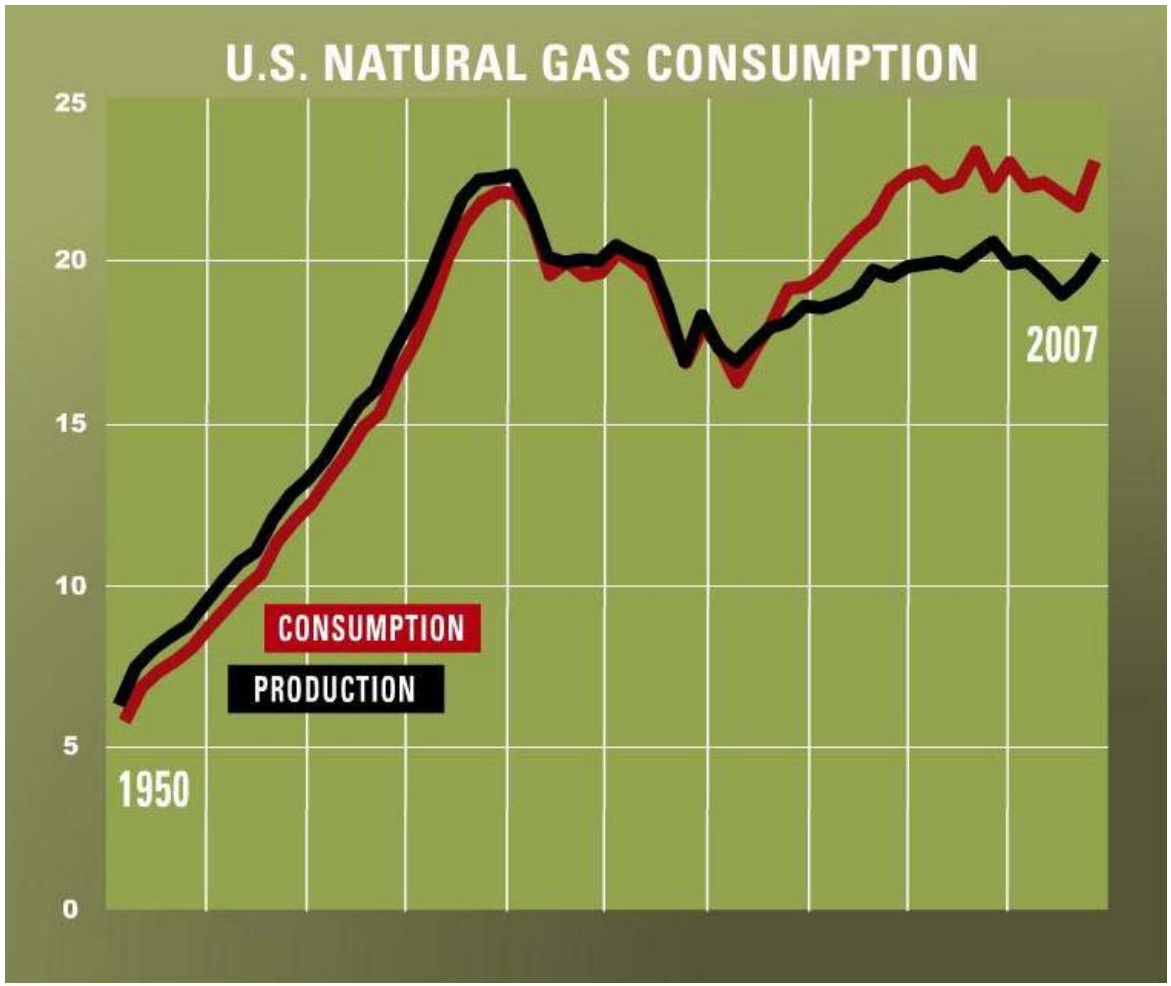
Why Shale Gas ?



courtesy: HALLIBURTON

Rebound in Gas Production

Tcf/a

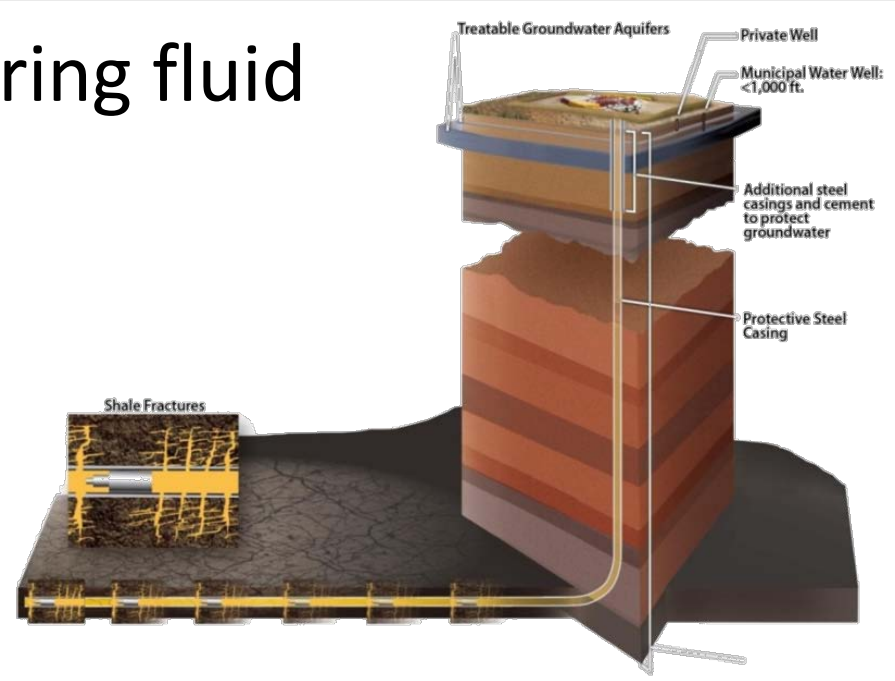


Year

courtesy: HALLIBURTON

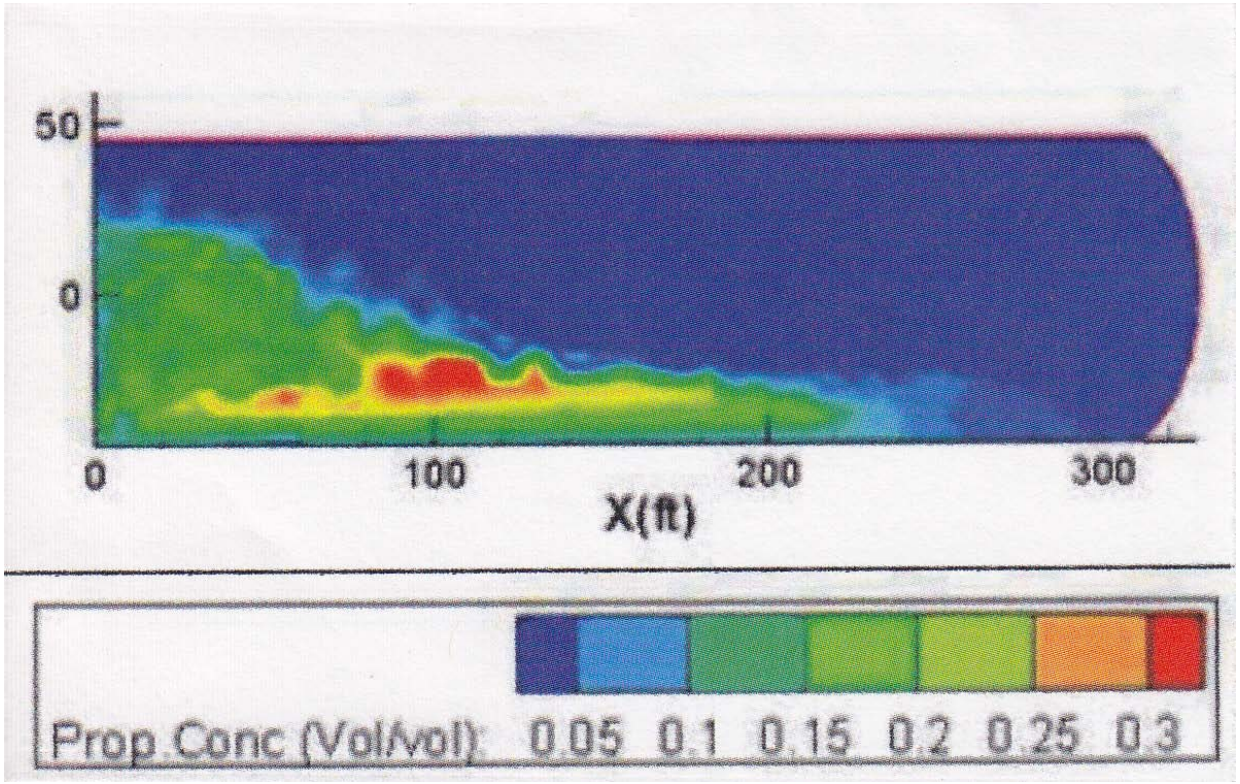
Key Issues with Shale Gas Production

- Low connectivity between pore space and well-bore: Multi-stage hydraulic fracturing
- Need long, narrow fractures; proppant settling
- Water needed for fracturing fluid
- Water disposal
- Public perception



Proppant Settling in Slickwater Stimulation

UTFRAC-3D



(Gadde et al., SPE 89875, 2004)

Project Objectives

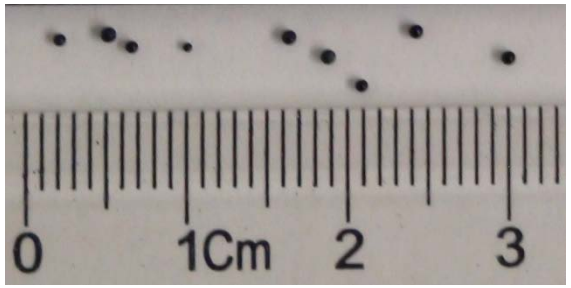
- To develop non-damaging fracture fluids for long fractures in gas shale reservoirs
- Minimize water use (and disposal)
- Demonstrate their use by field tests

Strategy: Ultra-light-weight proppants & foam

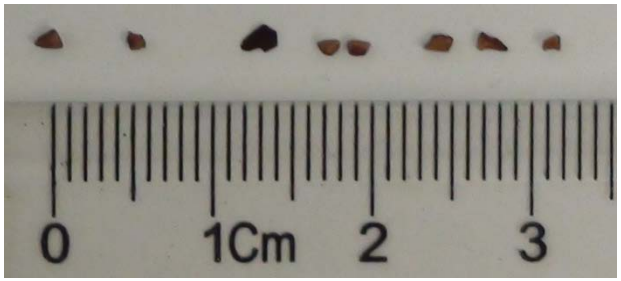
Tasks

- Proppant properties
- Foam formulation
- Flow capacity
- Proppant transport
- Fracture design
- Field test

Ultra Light Weight Proppants (ULW)



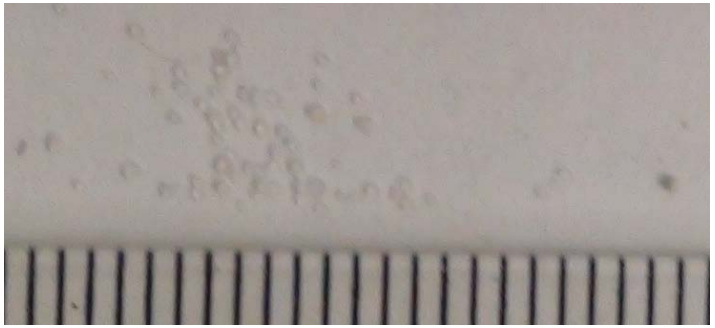
ULW1 (Polymeric)



ULW2 (Resin impregnated Walnut hull)

ULW3 (Resin coated Ceramic)

(Supplied by BJ Services)



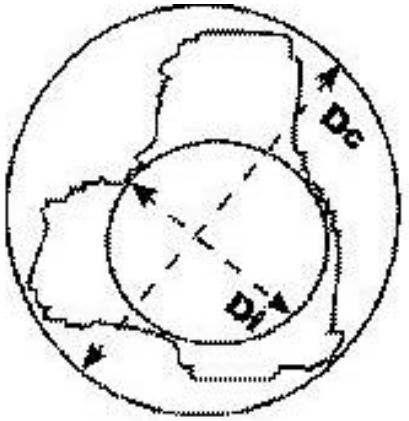
Reference: White Sand

Results

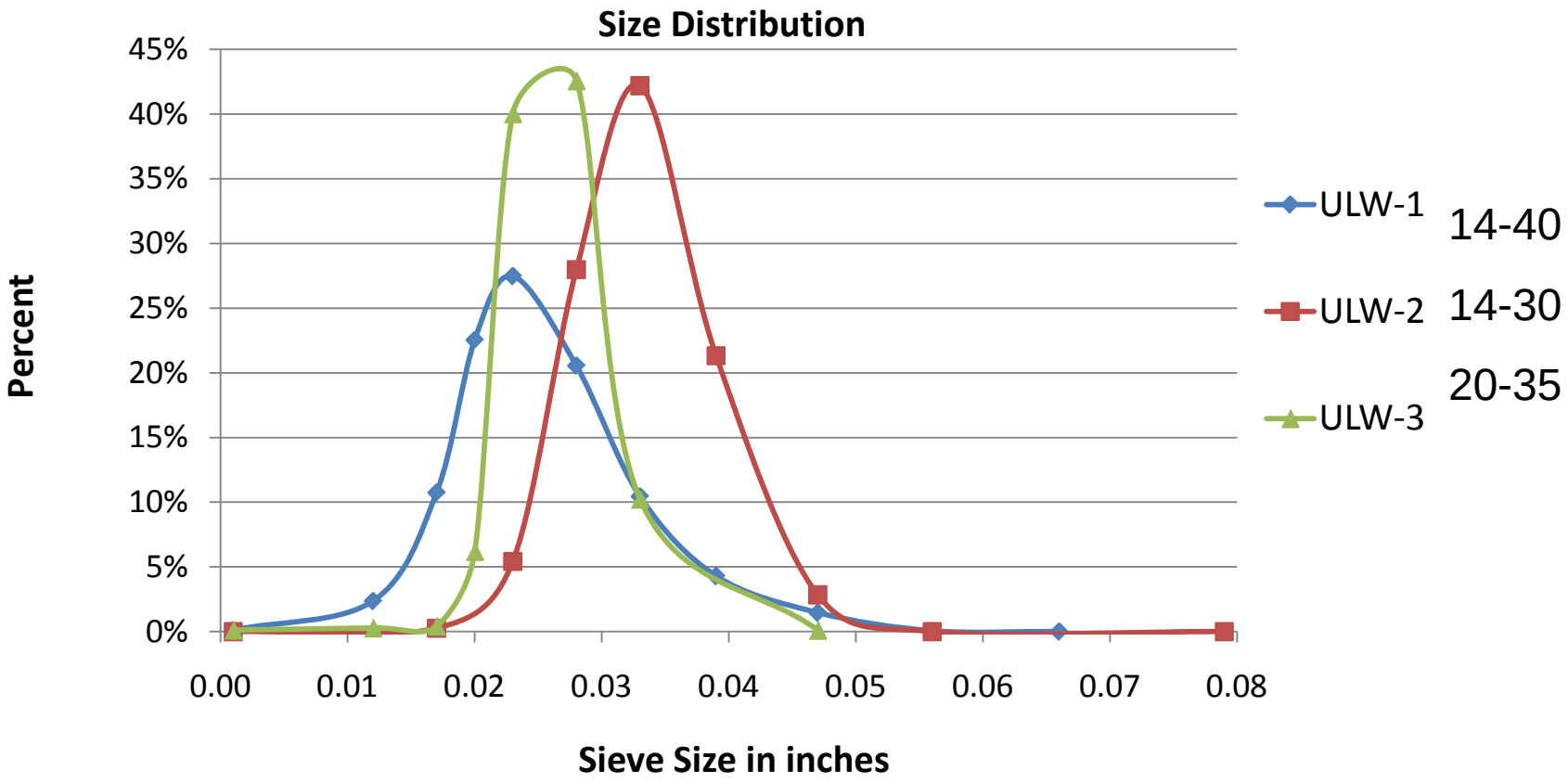
	ULW-1	ULW-2	ULW-3
Nominal density	1.08	1.25	1.75
Density of Pack (g/cc) (without closure stress)	0.6	0.8	1.2
Porosity of Pack (without closure stress)	44 %	36 %	31%
Sphericity	1	0.62±0.7	0.78±0.1

Riley Sphericity

$\Psi_R=(D_i/D_c)^{0.5}$

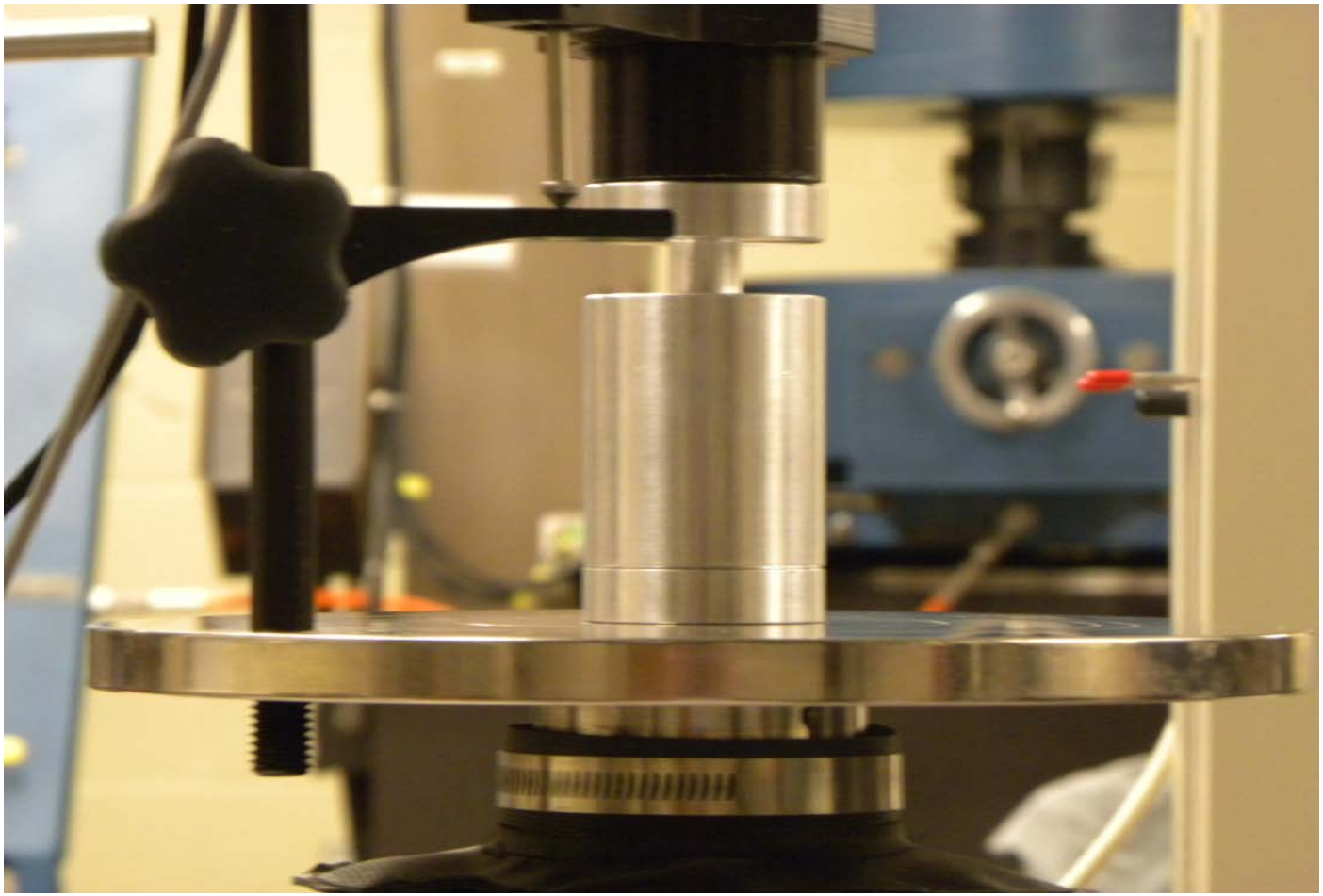


Size Distribution

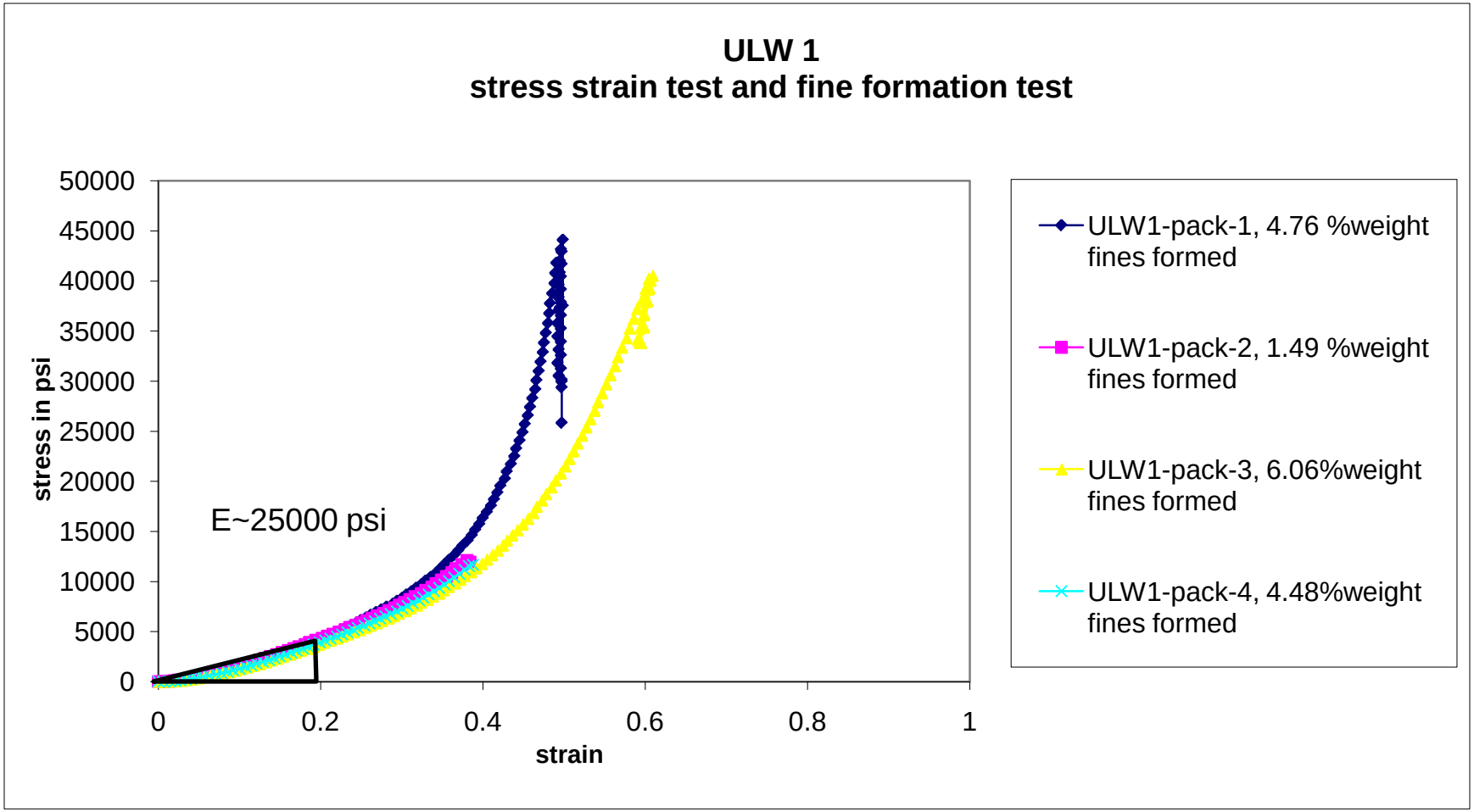


ULW1 is broadest; ULW2 is largest; ULW3 is narrowest.

Strength Test Tool

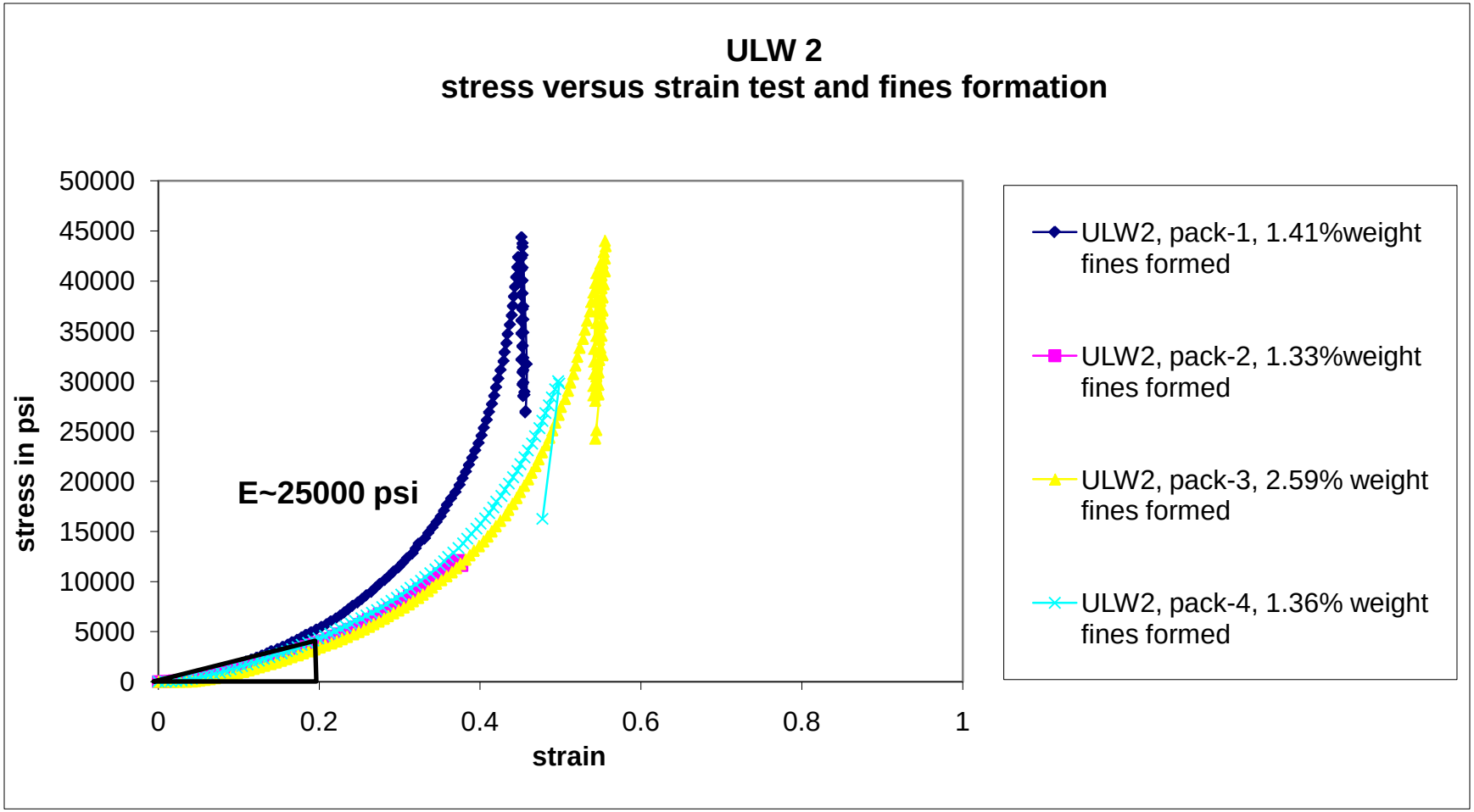


Strength Test of ULW1 Pack



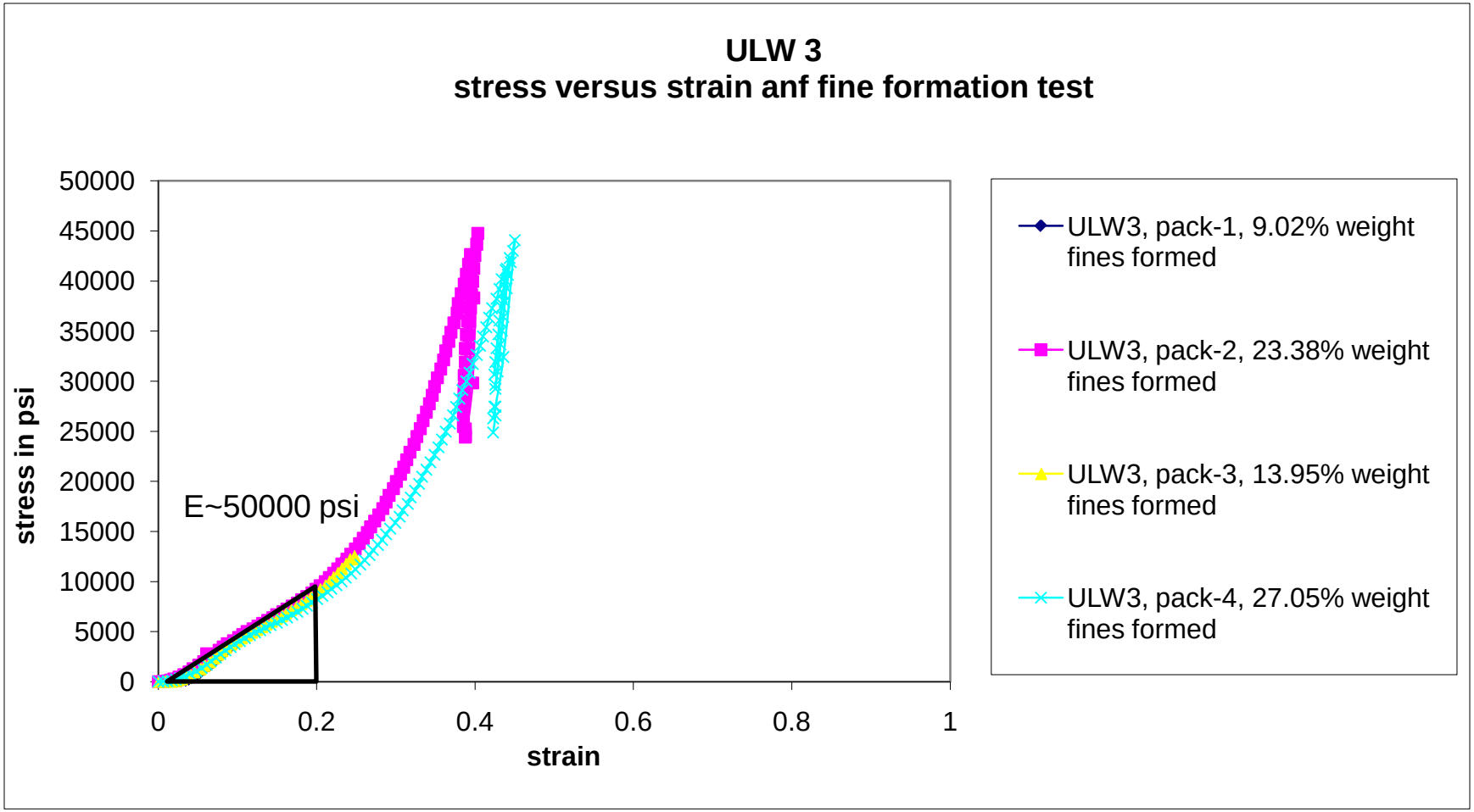
Maximum stress ~41,000-45,000 psi

Strength Test of ULW2 Pack



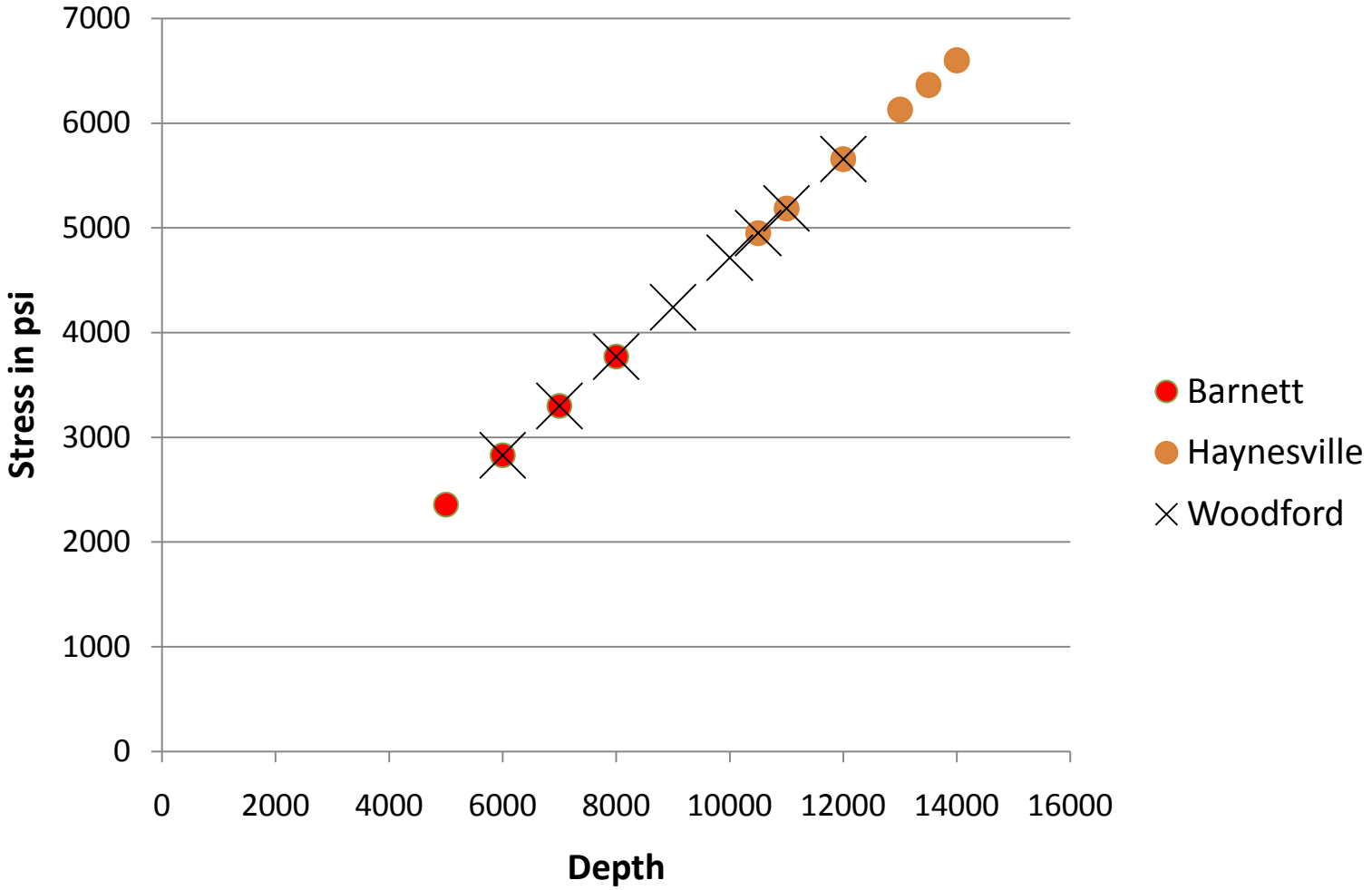
Maximum stress ~30,000-40,000 psi

Strength Test of ULW3 Pack



Maximum stress ~45,000 psi

Minimum Horizontal Stress

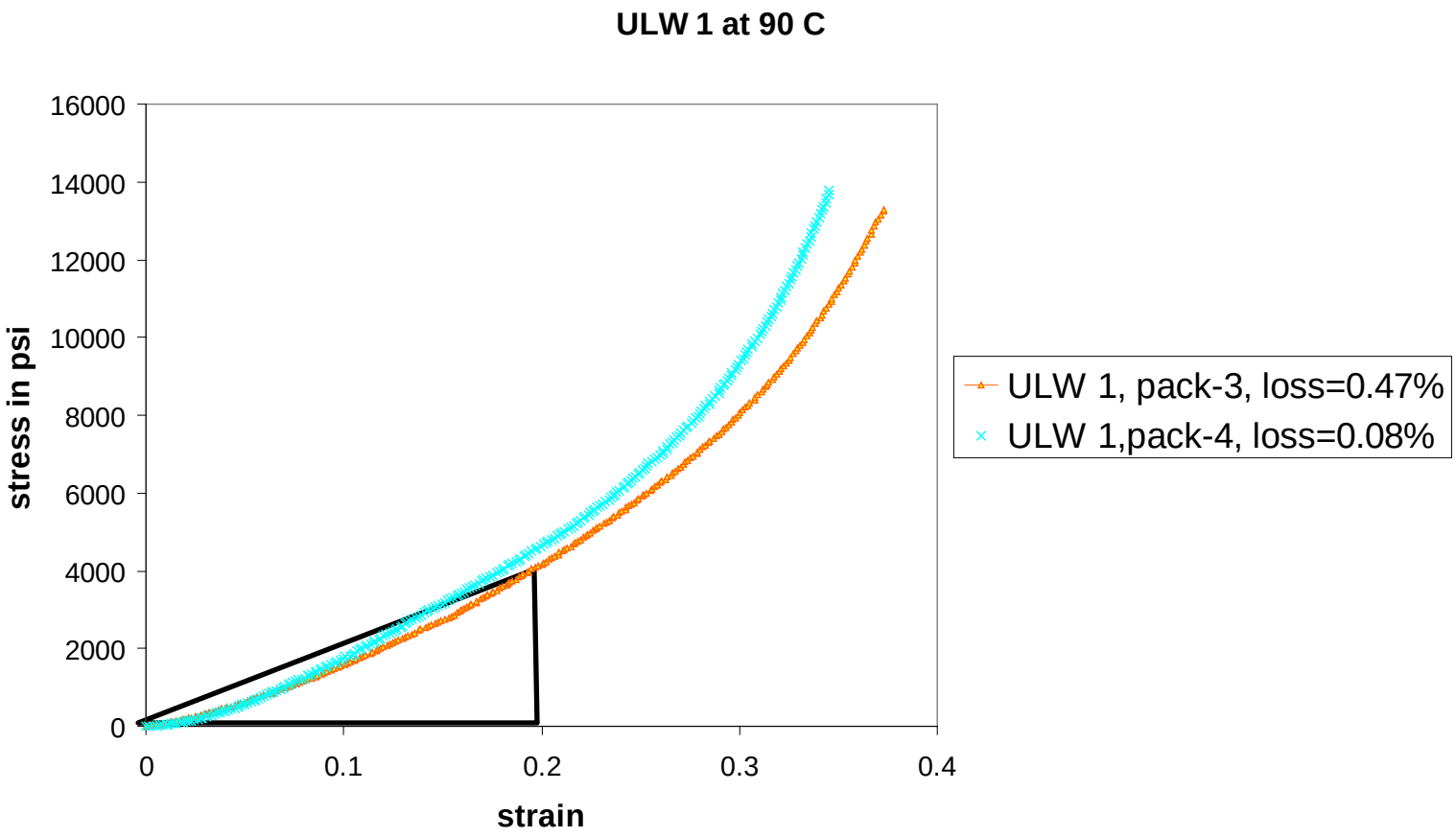


Fines formation

	Maximum stress reached <= 45000 psi	Maximum stress reached <= 45000 psi	Maximum stress reached <= 30000 psi	Maximum stress reached <= 30000 psi
ULW 1	**4.76 %**	**6.06 %**	**1.49 %**	**4.48 %**
ULW 2	**1.41 %**	**2.59 %**	**1.33 %**	**1.36 %**
ULW 3	**23.38 %**	**27.05 %**	**9.02 %**	**13.95 %**

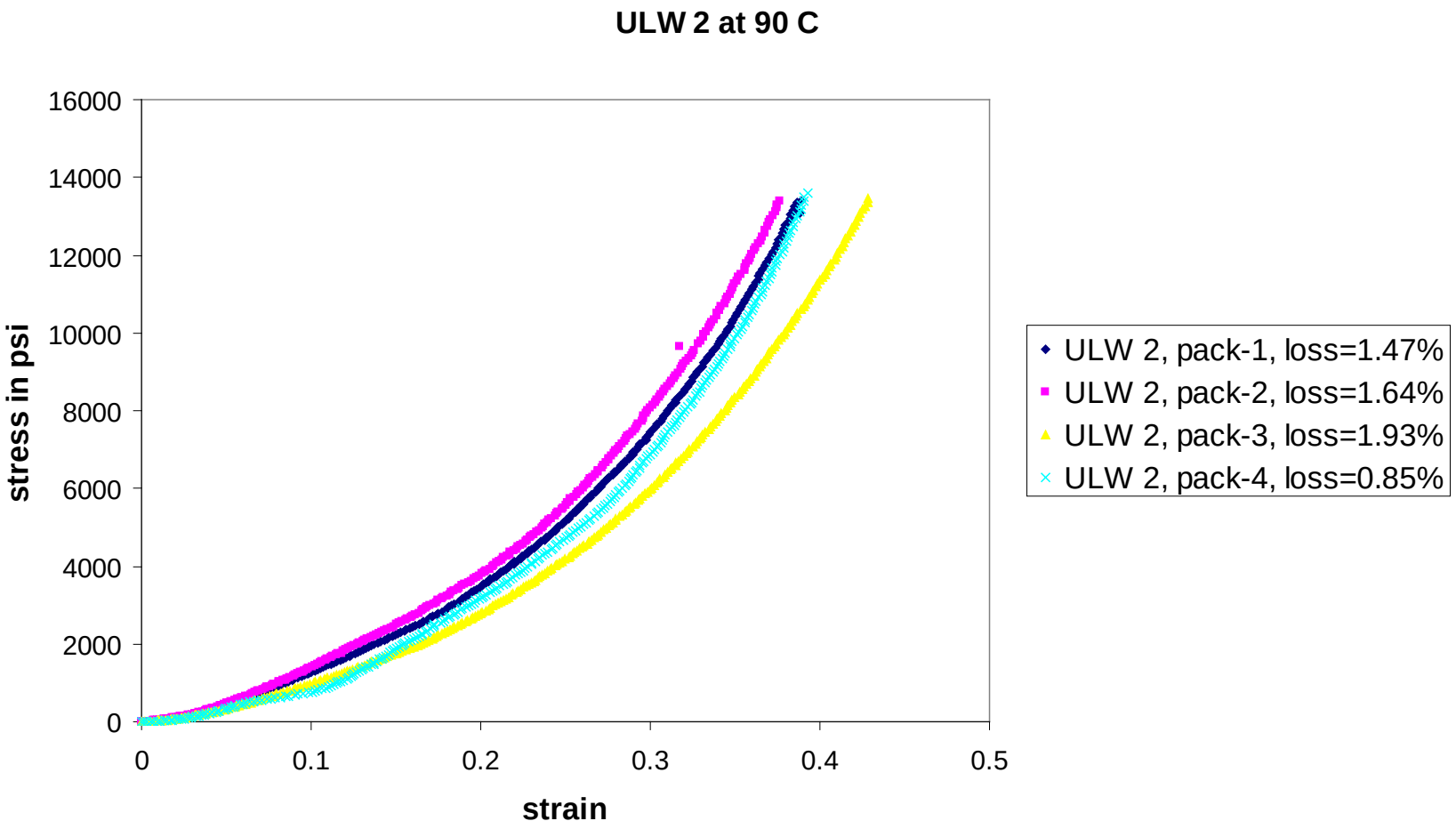
ULW3 forms the most fines.

Strength Test of ULW1 Pack, 90 C



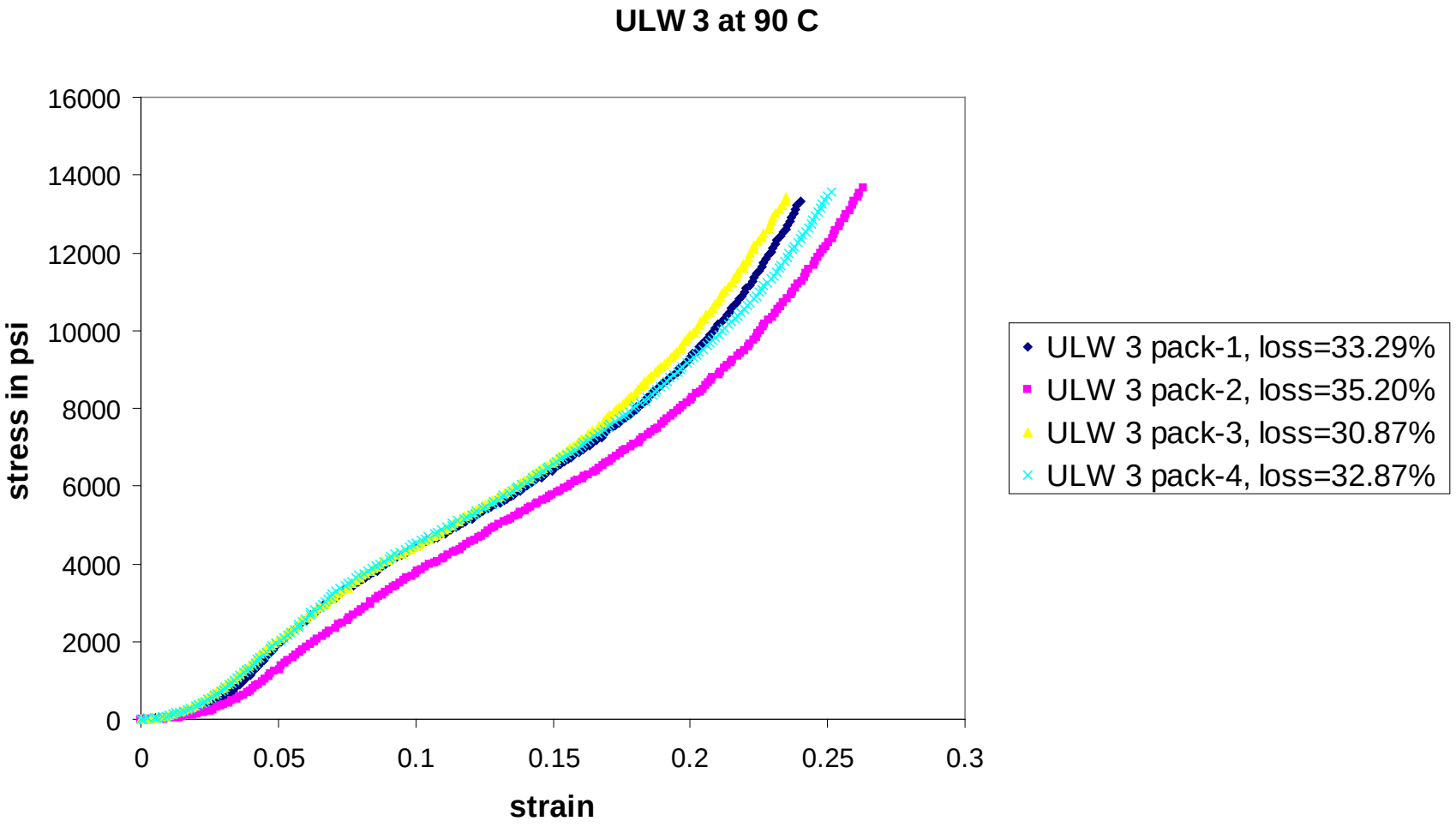
E ~20,000 psi

Strength Test of ULW2 Pack, 90 C



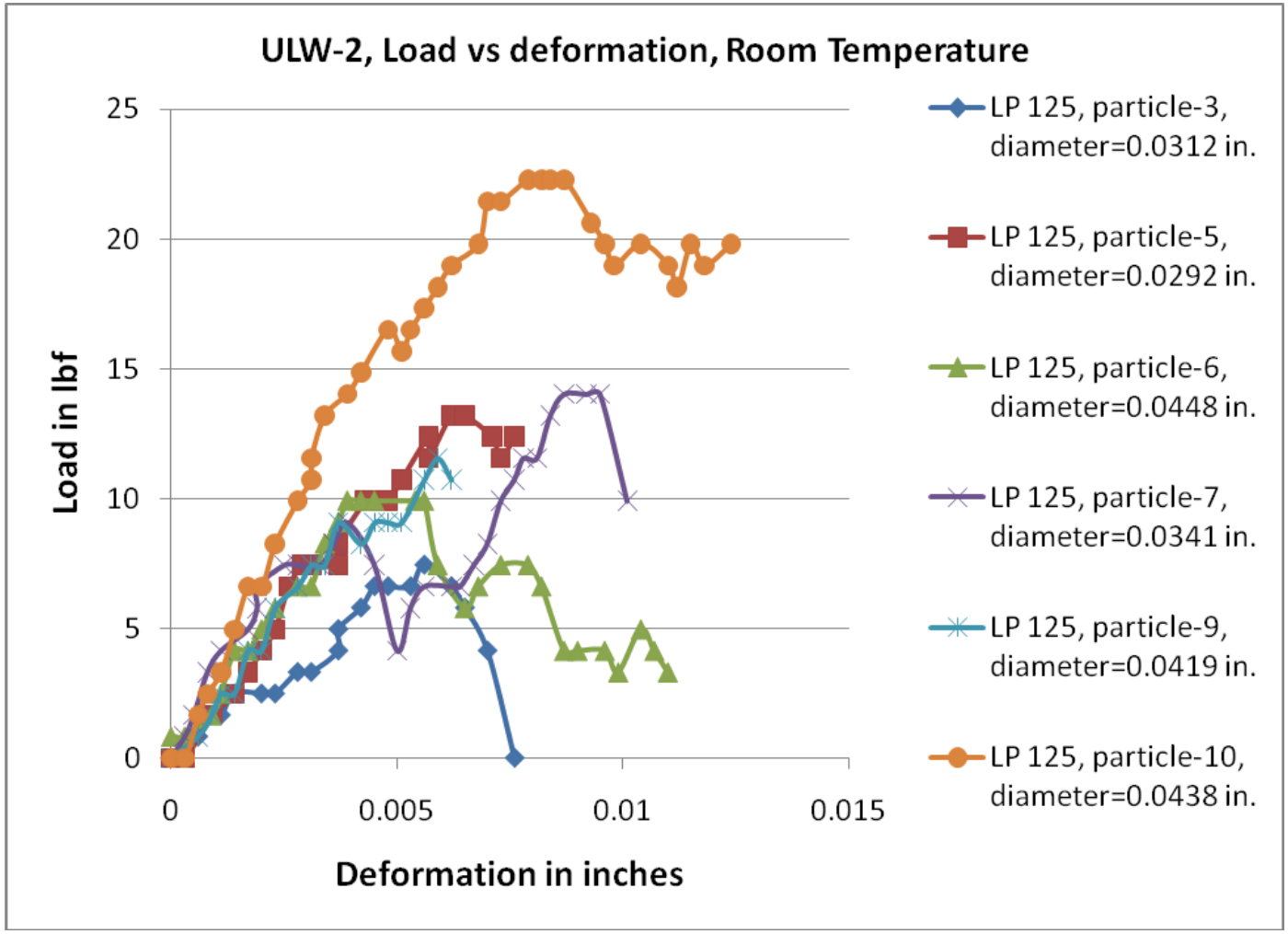
E ~20,000 psi

Strength Test of ULW3 Pack at 90 C

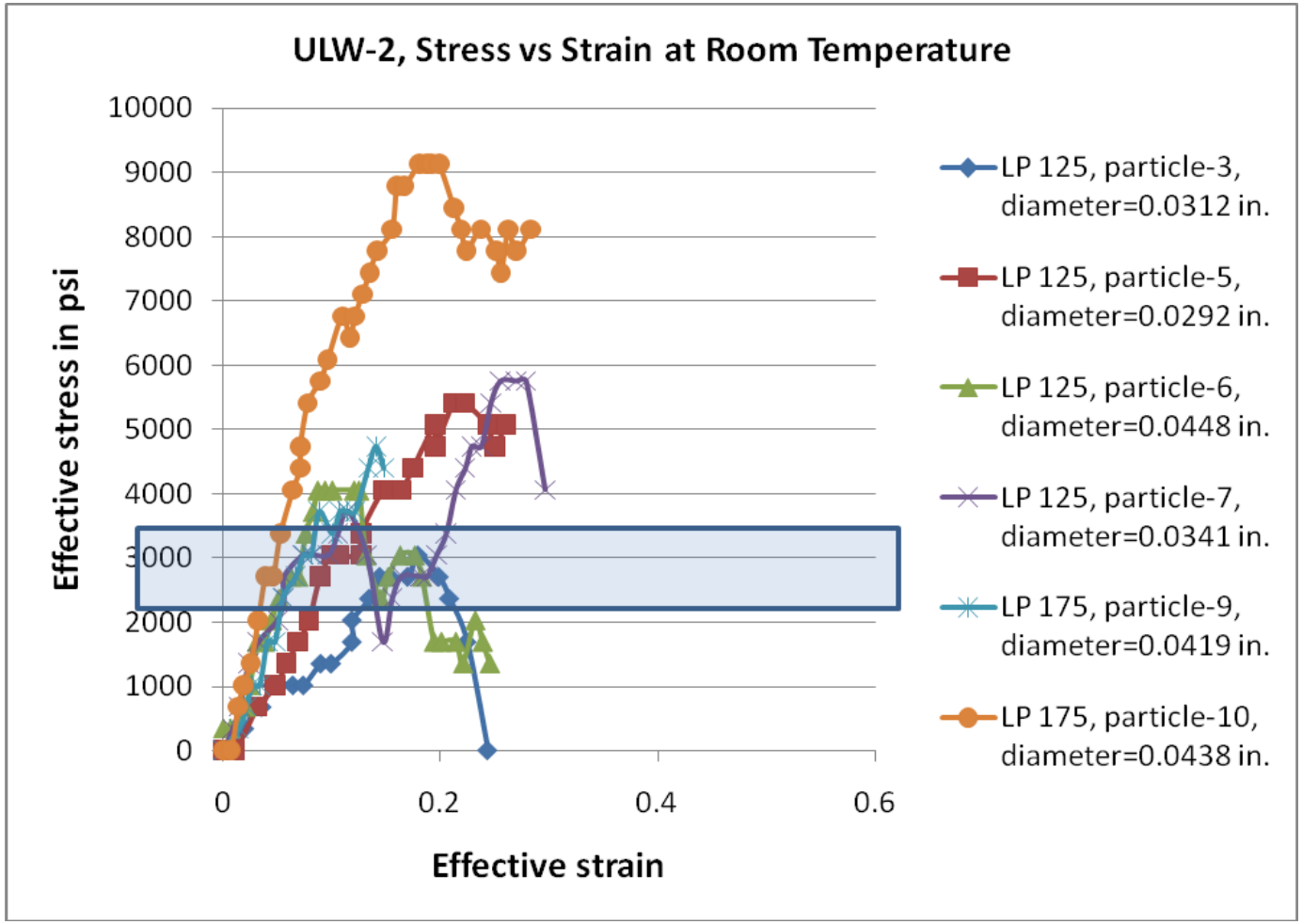


E~40,000 psi

Strength of Single Proppants



Strength of Single Proppants



Foam Fracturing Fluid

1. Less water consumption

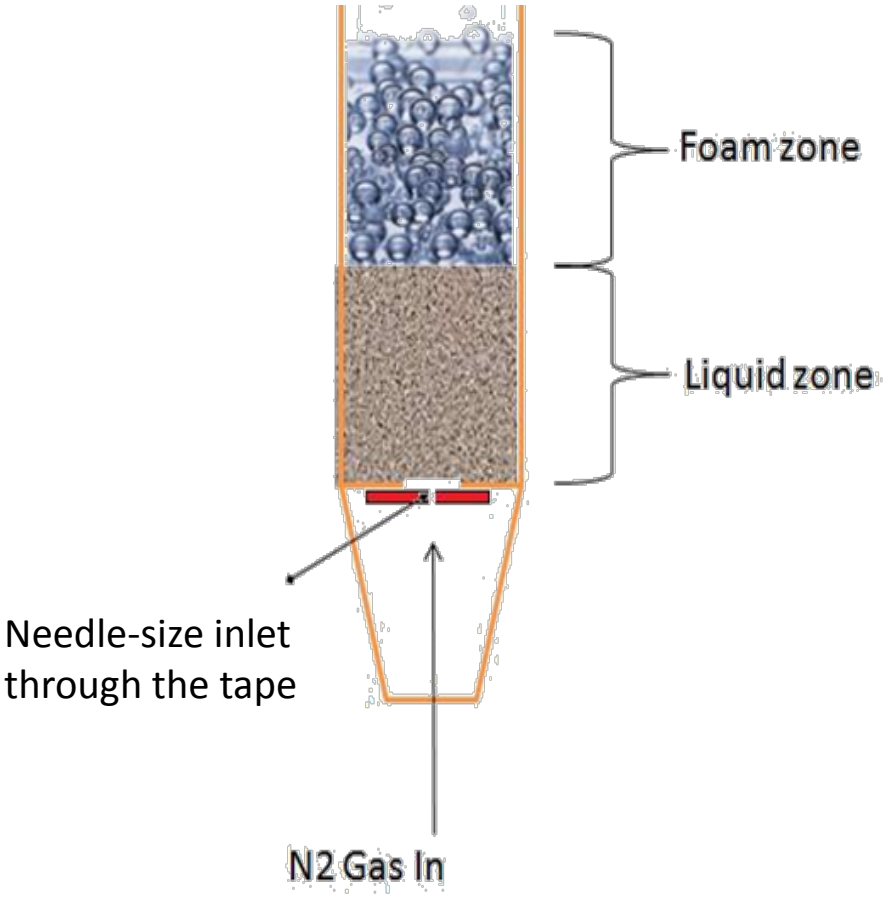
2. Gas expanding after the treatment to help recovery of the liquid phase

3. The two-phase structure has high viscosity

4. Gel filtercake deposited on the formation face is thinner (control the fluid loss)

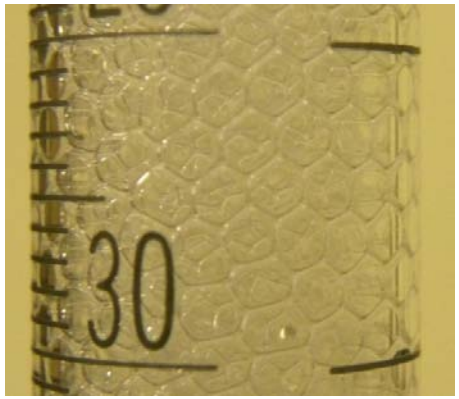
5. Little proppant is produced if the flowback rate is kept low.

Experimental Setup for Stability Test



Schematic figure of the setup

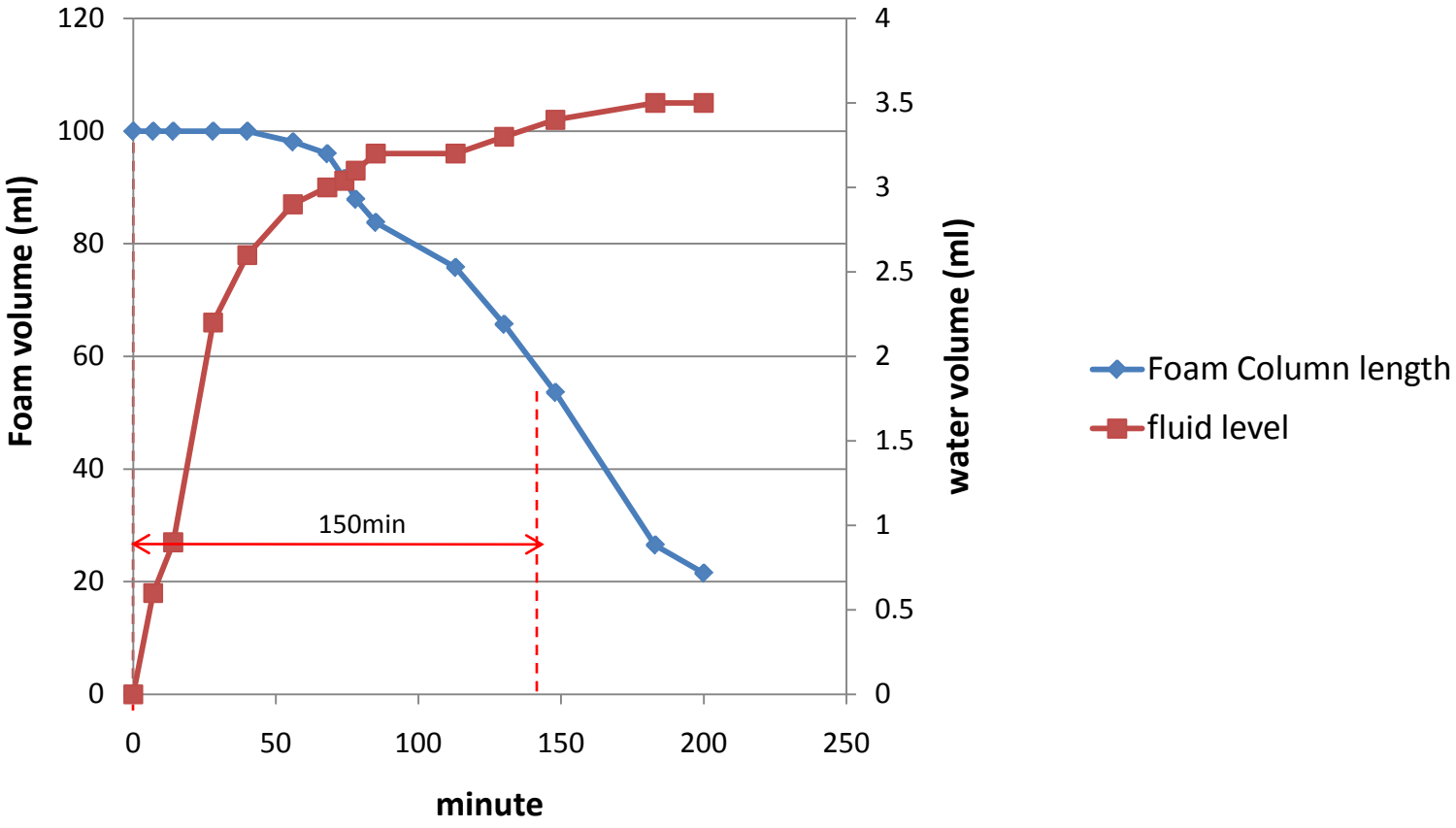
Bubble size:1mm
(low flow rate)



Bubble size:2 mm
(high flow rate)

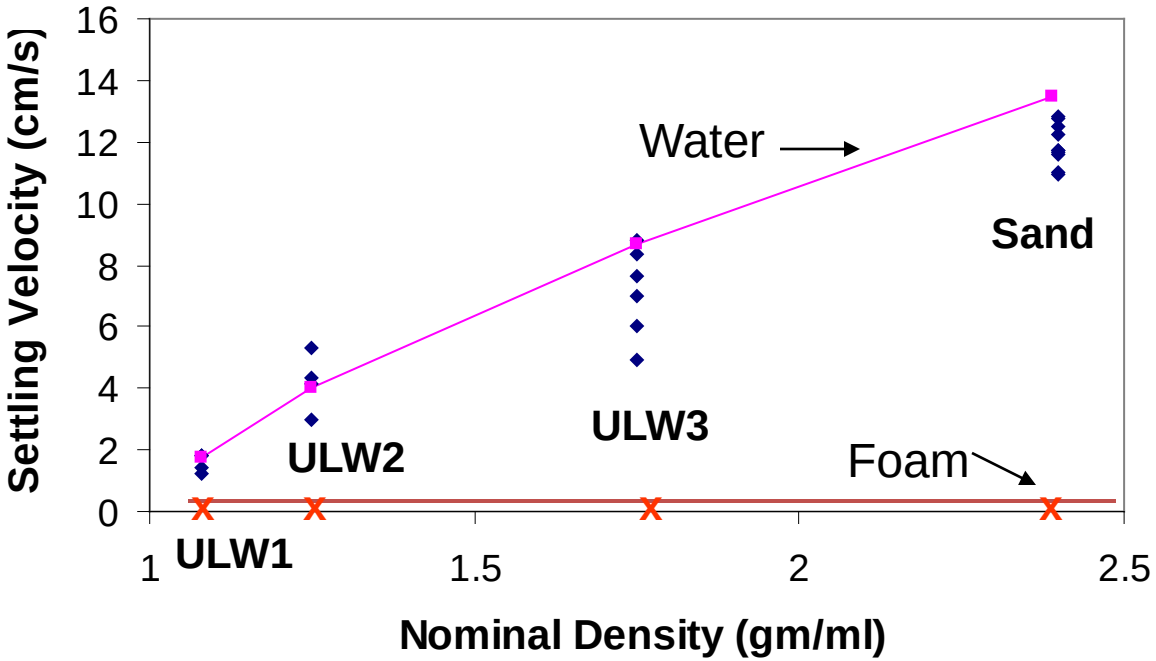
The bubble picture

Foam Stability



Foam half-life ~ 150 min

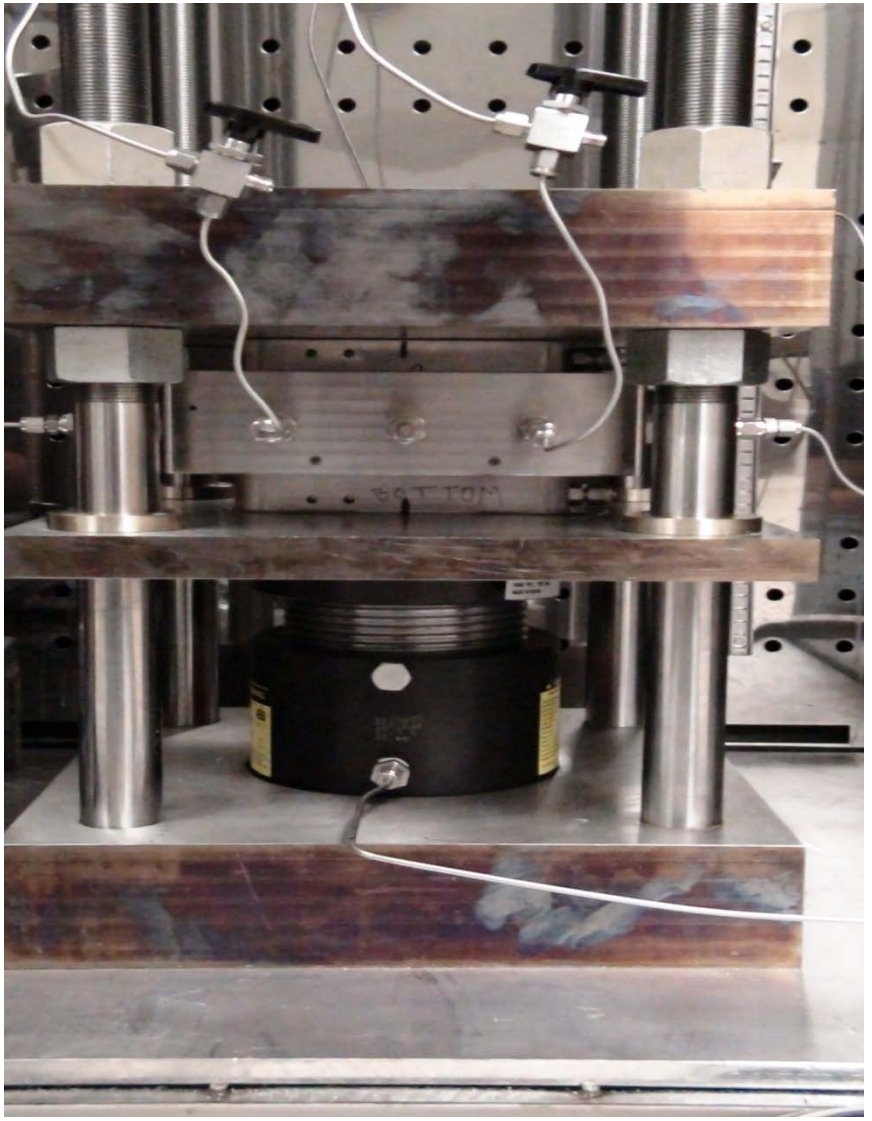
Settling Velocity (V_s)



- $V_s = [0.072g(\rho_p - \rho_w)]^{0.71} d^{1.14} / \rho_w^{0.29} \mu^{0.43}$ for water
- $V_s = 0$ for all the proppants and the sand in foam

Future Work

- Measuring proppant conductivity
- Dynamic proppant settling and transport
- Rheology of foam-proppant slurry



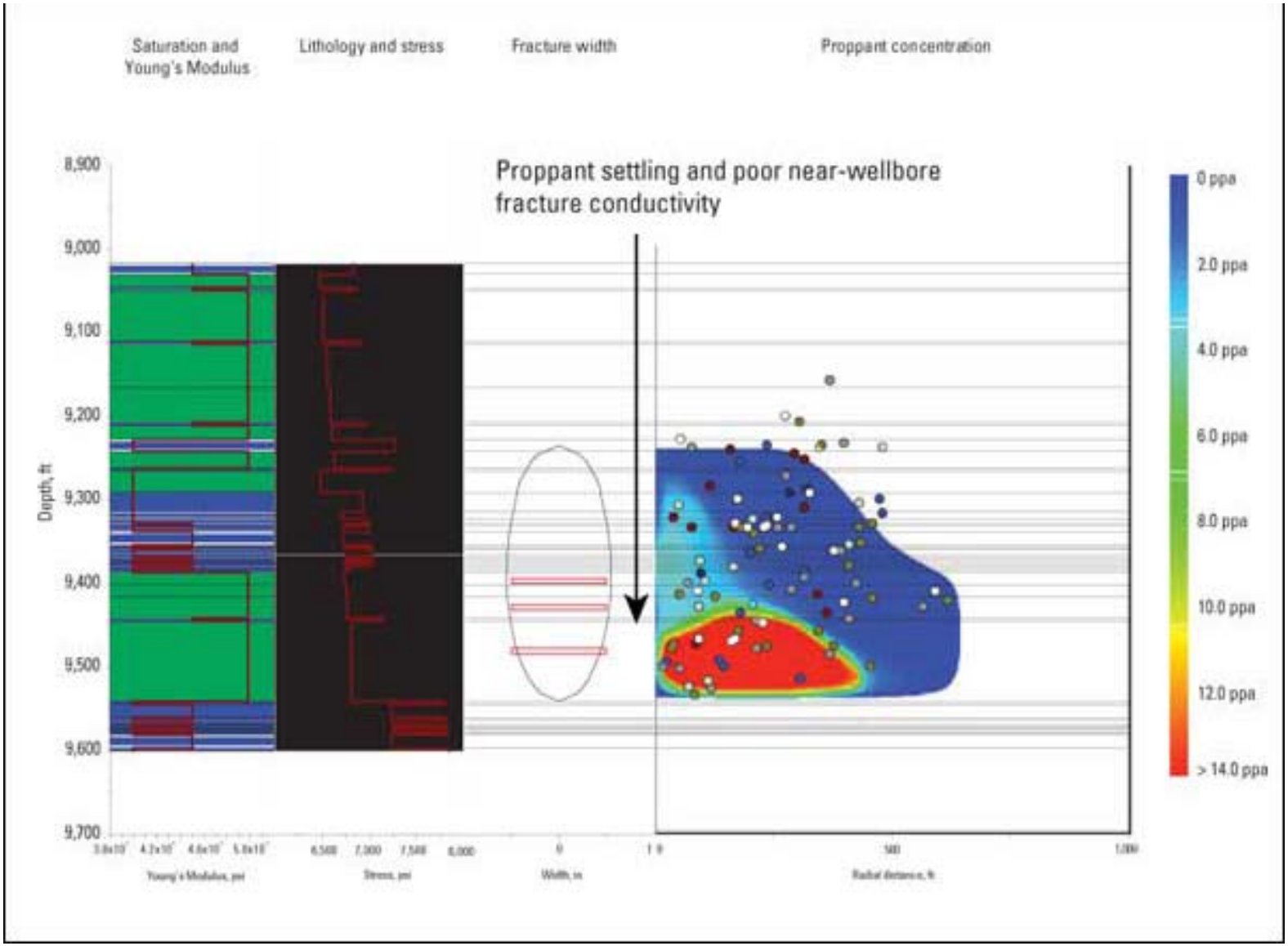
Conclusions

- ULW proppant packs can endure stresses expected in Barnett shale; conductivity will be measured before recommendation for use.
- ULW1 and ULW2 produce small amount of fines; ULW3 produces large amounts of fines at high stress.
- Foams can be formulated that are stable during the fracturing process.
- The settling velocity increases with proppant density in water; settling is negligible in foams in static tests.

Acknowledgements

- RPSEA
- Dr. Q. Qu & Dr. T. Pisklak, BJ Services
- Dr. A. Daneshy, Daneshy Consulting

Proppant Settling in Slickwater Stimulation



(www.slb.com/.../stimulation/stimmap_gas_cs.asp)