# **CARBO**<sup>®</sup>....provides industry leading technology for:



### **Production Enhancement**



**Barclays CEO Energy-Power Conference September 2-4, 2014 Investor Presentation** 

"One of the biggest economic opportunities in the oil and gas industry is to increase the recovery factor. In the shale reservoirs we are leaving <u>over 90%</u> of the oil in the ground."

**Fracturing Technology Evolution** 



### Shale Reservoirs – Need For Improved % Recovery

### Tighter rock needs fracs with more Contact Area and Conductivity



### To Increase Recovery In Shales.....We Need

### Contact Area

- To be economical, low perm reservoirs require large contact areas to drain
- Create multiple transverse fracs, in a horizontal well, & place large volumes of proppant
- Create complex fractures by using techniques such as slickwater, more stages, & more perf density to enable more frac initiation points
- Complex network fracture creation is dependent on formation factors, including brittleness



### **Conductivity**

- Convergent Flow from Transverse Fracs creates enormous flow velocity near wellbore, and choke points
- Overcome convergent flow issues with high conductivity tail-in proppant
- Overcome the reduced flowrates caused by multi-phase flow in these liquid rich reservoirs, with higher conductivity fracs
- The proppant needs to be strong enough to withstand the increasing closure stress and cyclic loading



### **Contact Area – Techniques To Create More**





- Dependent upon the reservoir, the industry has attempted several methods to create more Contact Area
  - Transverse fracs in horizontal wells
  - Longer laterals
  - # Stages, spacing, perf density
  - Zipper fracs
  - Frac Fluids crosslinked, linear, slickwater, hybrids
  - Smaller mesh proppant for transport
  - Microseismic to measure
- Progress has been made, <u>however</u>....
  - Most wells are still under stimulated
  - Recovery % is still too low



### **Contact Area – Creating Complex Network Fracs?**



#### "One Size Does Not Fit All"

- The Brittleness of the shale reservoirs greatly influences whether a complex network frac is being created, or a more planer-type frac.
   Ex. Barnett *‡* Eagle Ford
- In softer rocks (lower Young's Modulus), more proppant embedment takes place.
  Therefore they need higher concentrations of proppant to achieve necessary
  Conductivity

SPE 115769, 136183



# **Conductivity - Connecting The Reservoir & Wellbore**





#### Vertical Well Frac

- 2 x 200 ft perfs provides 400' linear feet of intersection with frac
- The frac height growth of a vertical frac and a transverse frac are assumed to be the same
- The difference is the much smaller area that hydrocarbons have to enter the transverse frac's wellbore

#### Horizontal Well Transverse Frac

SPF 146376

- The 6" casing provides 1.6 linear feet of intersection with frac
- Hydrocarbons must travel 250 times faster due to converging flow. Pressure losses are proportional to velocity-squared
- 250<sup>2</sup> = > 62,500 times greater pressure loss
- Always need more <u>Conductivity</u> near wellbore in transverse fracs

### **Conductivity – Multi-phase Flow Restricts Production**





- Modest liquids addition of 2 bbl/day, reduces effective conductivity 60 to 70%
- Overcome with higher **Conductivity** proppant

**Test Conditions:** 

6,000 psi, 250°F, zero gel damage, 2 lb/ft<sup>2</sup>

SPE 106301

- Flow: 500 mcfd, 2 blpd, 1000 psi bhfp
- 20 ft pay, YM=5e<sup>6</sup> psi

### **Conductivity - Effects of Pressure on Sand**

#### Conditions:

- **9,000 psi**, 250 F
- Flowing 2% KCL for 30 days
- Cross sections of Proppant pack shown
- At 9,000 psi, the Sand experienced severe crushing and the conductivity was only 215 md-ft

Sand Crushes into fine particles

- Loss of frac width
- Particles plug flow channels
- Leads to loss of Conductivity

### Northern White Sand 20/40



#### Conductivity = only 215 md-ft

### **Conductivity - Sand Crushes at High Pressure**

Sand crushes

and limits oil

**Reduces EUR** 

& gas flow.

#### White Sand @6,000 psi stress

#### White Sand @10,000 psi stress





....most wells are conductivity limited with Sand

### **Conductivity – Proppant Comparisons**



# **Conductivity – Flow Through The Proppant Pack**

Animation depicts flow through a 16/20 Low Density Ceramic proppant pack, @2 lb/ft<sup>2</sup> and 4000 psi

ISO Test Conditions: Velocity at 2 ml/min



$$\Delta$$
 P/L =  $\mu$  v / k

**Darcy Dominated** 

**Production. Enhanced.** 

Well Conditions: 100 bopd, or 120 MSCFD at 1500 psi BHFP



# $\Delta P/L = \mu v / k + \beta \rho v^2$

Inertia Dominated

Forcheimer's equation

### **Conductivity – Proppant Options To Increase % Recovery**









• Sand will have lower Conductivity and EUR

Sometimes 100 mesh Sand is used as a lead-in proppant in slickwater, with expectations it will propagate the fracture network further from the wellbore, given its transport capabilities. The downside is the very low conductivity of 100 mesh.



 Often, a combination of all three will be incorporated. Lead with 100 mesh Sand, followed by Sand, and tail-in with Ceramic for strength and higher conductivity. <u>Optimize the</u> <u>percentages to fit the reservoir characteristics.</u>

"What is the right balance between initial Investment and maximizing Recovery %?"



#### **Shorter Term Perspective**

### **Longer Term Perspective**

EUR (BOE)

### AFE (\$)





**Shorter Term Perspective** 

#### **Fracs Are Not Optimized**

**Longer Term Perspective** 

**Reasons to Optimize Fracs** 



"Over 150 SPE papers have been written documenting the benefits of increased conductivity on well Production and EUR. Generally, the payout on the additional **Proppant investment is less than 2 - 6 months,** and increases Production and EUR in a range of 20% to 100%."

**Case Histories** 

### **Bakken - Statoil**

# **Mountrail County**



**Production. Enhanced.** 

SPE Paper 134595 & 146376 – Brigham Exp/Statoil

### **Bakken - Liberty Resources**

# **Williams County**

### Model Validation – 3 Completion Types 180-Day Calc Cum Oil

### 1280ac Wells

Avg Values	Operator A	Operator B	Operator C						
# wells	49	259	372						
Gross MB	39'	41'	47'						
WC	53%	46%	41%						
Lbs/Ft	405	390	295						
Ft/Stg	275	285	340						
Bbls/Ft	25	8	5.5						
% Sand % Ceramic	0% 100%	38% 62%	66% 34%						
180 Day Cum Oil	81,000	73,000	56,500						



- Liberty Resources has lead the way in increasing **Contact Area** and **Conductivity**
- Higher well production results compared to offset wells, has verified the technical success of their completions

### Liberty Resources – Leader in Contact Area & Conductivity

"In liquid-rich or unconventional oil reservoirs, operators have typically sacrificed some contact area to maximize fracture conductivity. They have done this by lowering fluid volumes, pumping gelled fluids, and altering completion practices.

"We came to the Bakken intent on maximizing both <u>Contact Area</u> and <u>Conductivity</u>. Our goal for a Bakken well is to expose five million square feet of reservoir contact area per well. So far the results have been very encouraging."

#### Typical Bakken Well

- 10,000' lateral, 35 stages, slickwater
- <u>Contact Area</u>: 5,000,000 ft2 reservoir
- <u>Conductivity</u>: Ceramic proppant





# **Bakken Operator – Optimizing Completion Design**



### Eagle Ford – Field Trial on Offset Wells, Karnes County



Offset Wells:

- One well with 30% white sand lead and 70% Ceramic tail-in
- One well with 80% white sand lead and 20% RCS tail-in
- 6,000 foot laterals. Completion parameters consistent.

1 <sup>st</sup> Year BOE Production Gain	16,704
Net \$ Gain @ \$92 Oil & \$3.25 NG	\$1,400,000
Conductivity Investment	<\$600,000>
1 <sup>st</sup> Year Net Value Gain	\$800,000
Payout on Conductivity	7 Months

### **Eagle Ford Operator – Optimizing Completion Design**



### **Eagle Ford - Operator Design Comparison**



**McMullen County** 

Chart Name	6 Mo - # Wells	2 Yrs - # Wells
Company A	11	0
Company B	2	2
Company C	35	5
Company D	18	10
Company X	14	4
Company E	2	0
Company F	10	0
Company G	34	3



# Small Mesh Proppant Study

#### **Production Drivers:**

 Initiated a study of the impact of using primarily small mesh sand, may have on a well's long term production

#### Preliminary observations:

- Early production governed by **Contact Area**
- Longer term production governed by **Conductivity**
- The early production (2mo, 6mo, 12 month) using large volumes of small mesh sand, can fall behind the later production (1 to 2 years) of wells using larger mesh or higher conductivity proppant
- The "rocks matter". High GOR wells have been shown to produce high early production no matter what proppant is used; however, the later production will likely be governed by conductivity.
- Opportunity to protect and improve long term production, with a tail-in of high conductivity ceramic proppant

### NorthEast – Field Trial on Offset Wells, Belmont County

2.4 x increase in sand/ft lateral yields 32% less Production



	Length (ft)	(Mlb)	No.	Normalized on 6,800 Lateral
CARBOECONOPROP	6,800	5.5	27	2.12 BCF
White Sand	9,000	17.0	38	1.61 BCF

### Permian Basin - Bone Spring Operators, Lea County



### Haynesville – High Stress Reservoirs Need Ceramic



### **Granite Wash – Ceramics Out-Produce Resin-Coated Sand**



~ 2.6 Million lbs proppant in each well
 4,100 to 4,600 ft laterals in Wheeler, County
 Direct Offset Wells

# **CARBO**<sup>®</sup>....a leading production enhancement company

### **FRACPRO**

- Frac Design
- Economic Optimization
- Reservoir Performance
- Post Job Analysis





- Frac Conductivity & Durability
- Production Assurance
- Fracture Evaluation
- Flow Enhancement

### StrataGen 🍣

- Well Site Supervision
- Frac Diagnostics & Optimization
- Field Development Optimization
- Reservoir & Formation Analysis

## **Technology to Increase the Recovery Factor**

- **KRYPTOSPHERE** creates a paradigm shift in improved proppant performance
- ICDS <u>Infused Chemicals Delivery System</u> creates a step change in the performance of production chemicals. We improve well performance with 'Proppant Delivered' treatments, which have a controlled release. In addition, we are putting Fracture Evaluation technology into proppant.



# **Proppant Delivered Technology Platforms**

**ICDS** 



"More Space to Flow"

Higher

# **Production Assurance - SCALEGUARD**

- Most effective scale inhibitor product in the industry
- Increases Production and EUR, and lowers L.O.E.
  <u>costs</u> for E&P Operators
  - Provides production protection for months/years
  - Reduces costly work-overs & pump repairs
- Chemically infused porous proppant with controlled release of scale inhibitor
- 12 wells completed recently in Rockies & N. Texas. Effective scale control, with controlled release as designed.

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- Expanding into other basins now
  - Bakken, Permian and Marcellus

#### **Production. Enhanced.**





PORE VOLUMES

### Flow Enhancement - CARBORPM

- <u>Increases Production and EUR</u> by improving the permeability to hydrocarbons in the propped fracture
- Minimize capillary pressures in propped fracture with neutral wettability
- Increase effective fracture conductivity
  - Improve fracture clean-up
  - Reduce multiphase flow effects
- Recent activity in Permian basin for several operators has shown favorable results







### **Fracture Evaluation - CARBONRT**

- Identifying proppant placement, helps identify production improvement
- Non-radioactive tagged proppant
  - Environmentally friendly, manufactured into proppant grains
  - Direct measurement of proppant placement
- In vertical wells, measurement of fracture height allows estimate of fracture geometry
- In horizontal wells, helps determine stage spacing and coverage
- Integrate with other measurements
  - Surface & downhole microseismic
  - Fiber optic temperature & acoustics
- Sold globally







Figure 5. Integrated HFS diagnostic results (Stage 8-2011). Only two of the sands show evidence of effective stimulation. These match the gas entries shown by PLT (perforations 8-1 and 8-3). Both NRT and early warm-back data from DTS indicate a limited frac height.

SPE 168603, Shell Pinedale



# **Hierarchy of Proppant Conductivity**

#### **Highest Production, EUR, ROI Highest Conductivity Ceramic - Engineered product** Ultra-conductive Ceramic **Ultra-high strength KRYPTOSPHERE Mono-size and spherical High strength Tier 1 – High conductivity** Uniform size and shape Ceramic **Thermal resistant** Tier 2 – Medium conductivity **Medium strength Resin-coated Sand** Irregular size and shape Low strength Tier 3 – Low conductivity Irregular size and shape Sand Sand - Naturally occurring product Chart prepared by and

Conductivity = Permeability of the frac x width of the frac =  $K_{frac} \times W_{frac}$ 



property of CARBO

### **KRYPTOSPHERE** is a paradigm shift in improved Conductivity

### **KRYPTOSPHERE HD**





- KRYPTOSPHERE HD is the strongest, highest conductivity Proppant commercially available today for the industry's deepest, highest stress wells
- Tested successfully @30,000 psi (industry API RP19C crush test)
- KRYPTOSPHERE HD has 4 times the conductivity of competitors Bauxite Proppant @20,000 psi
- Superior Shape, Surface, Microstructure, and Durability



# **Ceramic Proppant Sales vs Capacity**

#### Lbs (Millions)



Millen Line 2 est completion near end of H1-2015 Environmental permits obtained for all 4 Millen lines



### New Technology Products Growth

# (Estimated)



### **Technology Products Growth**

- New Production
  Enhancement products
  being commercialized
- Expected to provide growth with higher margins than base proppant products

New Technology products do not include any sandbased products.

Includes KRYPTOSPHERE, Production Assurance, Flow Enhancement, Fracture Evaluation, Other Coated products, HYDROPROP.



"Proppant is one of the biggest factors in determining Production and EUR in fracture stimulated wells. It is important that E&P Operators know what Proppant is being used in their wells. Make sure you are getting the Conductivity and Quality you are paying for."

**Proppant Conductivity and Quality in the industry** 



Industry Awareness of Low Quality Chinese Ceramics

<u>The Stakeholders</u> - E&P Operators, Service Companies, Royalty Owners, State Agencies.....

- .....are becoming more aware of the losses to well Production and EUR that can occur when using low quality, **low conductivity Chinese ceramic proppants,** or other low quality proppants, and the subsequent loss of revenue
- .....are becoming more aware of the need to test Proppant and know what they are paying for. CARBO is committed to quality and testing – everyday.



### **Proppant Quality Matters in Well Production**

As an E&P Operator investing \$4M – \$12M on a well, how much Production & EUR are you sacrificing by using low quality <u>Chinese</u> ceramic proppant?



#### **Bottom Row Represents Whole Pellet Cross Sections**

#### **Production.** Enhanced.

flowrates

Increases

Field Samples #1, #2, #3 taken in North **Dakota from 3 Chinese Suppliers** 



### CARBO vs Low Quality Chinese Ceramic

Comparison of three field samples from North Dakota from low quality, low Conductivity <u>Chinese</u> ceramic proppant suppliers, compared to **CARBOLITE** :



#### **Bottom Row Represents Whole Pellet Cross Sections**

#### **Production. Enhanced.**

Field Samples #1, #2, #3 taken in North Dakota from 3 Chinese Suppliers



# Bakken Operator Field Trial CARBO vs Chinese

#### 30 Day Cum Oil

\*EUR



**ECONOPROP** Chinese IDC Average Average

#### **Production. Enhanced.**

Chinese IDC

Average

ECONOPROP

Average

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# Finance



### Q3-14 Operations Update

- KRYPTOSPHERE Patent allowed on our innovative, high conductivity proppant
- KRYPTOSPHERE HD
  - Targeting 12 to 16 GOM Lower Tertiary wells in 2015. Strong likelihood that KRYPTOSPHERE HD will be used by a client in a deep well application during Q4-14.
- SCALEGUARD
  - Commercialization is underway, expect incremental margins over base ceramic proppant. Large opportunity in liquids-rich, multi-phase flow wells.
- Bakken Operations
  - A number of multi-well pads in the Bakken are scheduled for quarter-end, the potential exists that one or more could slip into Q4-14. Experiencing some completion delays due to rain.
- We are confident we can replace the volumes associated with the recent (1) client loss, with other client(s)
- Q3-14 ceramic proppant volumes may be similar to Q2-14 results



### **CARBO** Financials



\* Cash from operations is equal to net income plus depreciation and amortization and non-cash stock compensation



### **CARBO** Financials



Cash Flow Per Share = Cash from operations (= net income plus depreciation and amortization and non-cash stock based compensation)/diluted shares



# **Dividends Increased - 14 Years**

#### \$ Per Share

**Shares - Millions** 





### Cash Flow from Operations Reconciliation

### Results from Continuing Operations \$ in 000s

	For The Years Ended Dec 31																		
		2005		2006		2007		2008		2009		2010	<b>201</b> <sup>2</sup>	1		2012	 2013		ТТМ
Net Income	\$	45,463	\$	52,245	\$	49,641	\$	60,405	\$	52,810	\$	78,716	\$ 130,	136	\$	105,933	\$ 84,886	\$	92,446
Plus: depreciation and amortization		10,935		15,630		19,895		24,638		24,905		27,728	36,	015		44,893	47,472		47,784
Plus: non-cash stock compensation				2,311		1,709		2,052		2,571	_	3,812	4,	719		5,335	 5,837		7,102
Cash Flow from Continuing Operations	<u>\$</u>	56,398	<u>\$</u>	70,186	\$	71,245	<u>\$</u>	87,095	\$	80,286	<u>\$</u>	110,256	<u>\$ 170,</u>	870	<u>\$</u>	156,161	\$ 138,195	\$	147,332
Weighted Average Shares Oustanding		24,177		24,400		24,451		24,418		23,112		22,977	23,	012		22,969	22,957		22,945
Cash Flow Per Share	\$	2.33	\$	2.88	\$	2.91	\$	3.57	\$	3.47	\$	4.80	\$ 7	7.43	\$	6.80	\$ 6.02	\$	6.42

Cash from operations is equal to net income plus depreciation and amortization and non-cash stock compensation

