

# **RECENT TECHNICAL ADVANCES IN SHALE PLAYS** – *PRACTICAL APPLICATIONS IN THE EAGLE FORD SHALE*

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You generally can identify forward-looking statements by the words "anticipate," "believe," budgeted," "continue," "could," "estimate," "expect," "forecast," "goal," "intend," "may," "objective," "plan," "potential," "predict," "projection," "scheduled," "should," or other similar words. Such statements are inherently subject to risks and uncertainties, including, but not limited to, those relating to the worldwide economic downturn, adverse market conditions and assessments, availability of financing, the Company's dependence on its exploratory drilling activities, the volatility of and changes in oil and gas prices, the need to replace reserves depleted by production, operating risks of oil and gas operations, the Company's dependence on key personnel, factors that affect the Company's ability to manage its growth and achieve its business strategy, results, delays and uncertainties that may be encountered in drilling, development or production, interpretations and impact of oil and gas reserve estimation and disclosure requirements, activities and approvals of our partners and parties with whom we have alliances, technological changes, capital requirements, borrowing base determinations and availability under our credit facility, evaluations of us by lenders under our credit facility, the potential impact of government regulations, including current and proposed legislation and regulations related to hydraulic fracturing, oil and gas drilling, air emissions and climate change, regulatory determinations, litigation, competition, the uncertainty of reserve information and future net revenue estimates, property acquisition risks, availability of equipment and crews, actions by our midstream and other industry partners, weather, availability of financing, actions by lenders, our ability to obtain permits and licenses, the results of audits and assessments, the failure to obtain certain bank and lease consents, the existence and resolution of title defects, new taxes and impact fees, risks associated with the trend towards increased anti-development activity, delays, costs and difficulties relating to our joint ventures, actions by joint venture partners, results of exploration activities, the availability and completion of land acquisitions, completion and connection of wells, and other factors detailed in the "Risk Factors" and other sections of the Company's Annual Report on Form 10-K for the year ended December 31, 2013 and other filings with the Securities and Exchange Commission ("SEC"). Should one or more of these risks or uncertainties materialize, or should underlying assumptions prove incorrect, actual outcomes may vary materially from those indicated.

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This presentation includes "non-GAAP financial measures" as that term is defined in Regulation G. The most directly comparable GAAP financial measures and information reconciling these non-GAAP financial measures to the Company's financial results prepared in accordance with GAAP are included at the end of this presentation.





# Who Is "Carrizo"?

## "World Class" expert at unconventional (shale) plays

- Operated the drilling of over 750 horizontal shale wells to date.
- Carrizo drilled over 105 horizontal wells in 2014 in the Eagle Ford, Niobrara, Marcellus and Utica.
- 155 MMBoe proved reserves, 480 MMBoe probable (de-risked) reserves.
- Average Eagle Ford horizontal length is 2,000 meters, with 3,000 meter horizontal completion (in a 6,600 meter well) and 42 frac stages drilled successfully.
- Horizontal wells are completed with 20 40 frac stages and micro-seismic is often used to optimize fracing.
- Leading expert at drilling in urban and environmentally sensitive areas.
- EURs of our wells consistently rand among the best in our core areas.

## **Operational Areas** – Then and Now . . .



Notes: Based on 06/30/15 internal reserves estimates and SEC pricing (\$71.68/Bbl and \$3.39/Mcf).

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## **Technical Efficiencies – Or Not?**

Experience! Experience! Experience!

## <u>Drilling --</u>

- New Modern Rigs
  - Larger Mud Pumps
  - Optimized With Downhole Assemblies to Specific Drilling Conditions
- Optimal Well Spacing Stagger Stack

## Completions --

- Optimal Sand Concentration in Frack Design not to much, not to little, but "just right"
- Engineered Perfs
- Diversion techniques (re-fracks?)
- Future Improvements such as Dissolvable Plugs

## **CRZO Eagle Ford Case Study – South Texas**



- Displays CRZO leases and industry completions at November 2014
- 10,800 Eagle Ford industry wells producing
  - Industry consistently running 200 – 250 drilling rigs during this period

## **Experience! Experience! Experience!** Drilling and Fracking Experience



# Approaching 10,000,000 total feet of hole (1,890 miles) in 5 primary play areas



#### **Over 9,400 Stages Fracked to Date**

## **Operational Improvement** *Continuous Improvement*



Frac Stages Pumped per Day 10 20 9 18 8 16 Frac Stages per Day 7 14 6 12 Wells on 5 10 8 3 2 1 Febria Navia Austa Novia Febris FEDTI NOVIT AUGUL NOVIT FEDTI NOVIT AUGUL NOVIT ---All Pads Pads with Well Count>1 Nell Count on Pad

- Since 2010 rig performance in terms of wells TD'd per rig has improved over 160%
- Generation 3 rigs are performing as expected
- Entire fleet Generation 3 rigs, permitting us to drop one out of three rigs without a material drop our activity
- Year-over-year, rig fleet as a whole drilled 16,781 ft. more hole per rig
- Lots of small wins add up to overall efficiency gains

# **Drilling Efficiencies**



## Modern Rig Technology – 3<sup>rd</sup> Generation



- Bi-Fuel Diesel and Natural Gas
- **1500 HP AC Electric Motors**
- 750,000 lbs Mast /w Top Drive
- **2000 HP 7500 psi Mud Pumps**
- Walking System
- Hydraulic Cat Walk
- Rotating Mousehole

## Modern Rigs Lead to --Continuous Improvement

#### Drivers behind improvement

- Learning Curve
- New Technology rigs, bits, directional tools
- Pad Drilling
- Batch drilling
- Results of the efficiencies gained
  - Reduced costs
  - Lower cost per unit
  - Better return on investment



#### Average Ftg Drilled per Day by Well

## **Optimal Well Spacing – An Evolution** 330 ft. Downspacing –Irvin Example



## **Optimal Well Spacing** 330 ft. Downspacing – Pena Winfield



## **Optimal Well Spacing – Beyond Downspacing** Stagger Stack – Potential to Materially Expand Inventory









- Current development
- 330 ft. effective spacing
- ~1,090 total locations at full 330 ft. spacing
- Full stagger stack
- 165 ft. effective spacing
- ~80% increase to inventory
- Partial stagger stack
- 220 ft. effective spacing
- ~45% increase to inventory
- Partial stagger stack
- 270 ft. effective spacing

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 ~20% increase to inventory

## **Optimal Well Spacing** *Micro Seismic*

- Concept
  - Utilize micro seismic events characteristics to define stimulated rock volume and propped rock volume
- Theory
  - A surface micro seismic array is capable of gathering data on the energy released and the orientation of shear fractures created during a frack treatment
  - There is a relationship between energy released during a shear failure and the fracture area created
  - The defined properly sized fracture sets are placed and oriented at the corresponding event point
  - Material balance models fills and grows the created fractures with the water and sand job volumes pumped during the frac job

## Micro-Seismic MicroSeismic Inc. – FracStar ™



## Micro-Seismic MicroSeismic Inc. – FracStar ™

Steps to create SRV (Stimulated Reservoir Volume) and PSRV (Propped Stimulated Reservoir Volume) model



## Eagle Ford Shale Stagger Stack



Utilize Microseismic to calculate SRV and PSRV and determine if Stagger Stack down spacing is viable

## **Eagle Ford Shale**

## **Optimizing the Development Program**



- Performance of 330 ft. spaced wells looks very similar to wells drilled at wider spacing in each area tested
- Testing further downspacing through stagger-stacks in the Lower Eagle Ford during 2015 – Results are positive
- Initial Upper Eagle Ford test on-line in 4Q 2015
- Continue testing a variety of completion enhancements including engineered completions, diversion techniques and fiber optic monitoring



# Completions

# **Optimal Sand Concentration in Frack Design**

Benchmarking Study – Stage Completion Design

CARRIZO EAGLE FORD WELLBORE DIAGRAM 7,800 bbls hybrid slick water (65%) Conductor 80' and cross linked 16" Conductor gel (35%) 380.000 lbs of Surface Casing ,000' - 5,000 sand; combination 14-3/4" Surface Hole, 10-3/4" 45.5ppf, J-55, STC OR TVD 12-1/4" Surface Hole, 9-5/8" 40ppf, J-55, STC of 100 mesh, 40/70 and 30/50 white sand 80 bpm average treating rate **Treatment Interval** 240' plug to plug Perf Clusters KOP 5 clusters on 40' Production Liner 10.0 %100' Curve ,500' - 10,250' 8 3/4" Hole, 5 1/2" 20 ppf, P-110, CDC TVD spacing TD = 14,000' - 19 8,500' - 10,

Fluid

Proppant

Rate

Frac Style

Zipper

## **Optimal Sand Concentration**

**Benchmarking Study – Completion Design** 





## **Optimal Sand Concentration** Benchmarking Study – Completion Design



#### **Average Proppant Placement by Operator for LaSalle County**

## **Optimal Sand Concentration**

Benchmarking Study – Pena Winfield and Gardendale



# **Optimal Sand Concentration** Benchmarking Study – Pena Winfield



# **Optimal Sand Concentration** Benchmarking Study – Gardendale



## **Engineered Completions vs. Geometric Completions**

#### Perforating



### Fracking



## **Engineered Completions**



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# **Engineered Completion Test –**

## Treating Results



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# **Engineered Completions** – *Performance Results*



## **Proppant Diversion**

#### Concept

- Utilize graded bead system to divert fluid and sand flow during a frack job to cause diversion within existing frac networks to create complexity
- Create diversion between stages to force more even fluid distribution

#### Theory

- Graded ball system works in same manner as lost circulation agents used in the drilling operations or for that matter like building a dam
- Start with larger beads to create a bridge
- Follow with smaller sized beads to plug the holes in the bridge

### Application

- Simple application
- Pumped midway through job in 150 lbs. batches

## **Proppant Diversion** West Pena Test -- Access Frac®



- All wells drilled with same effective lateral length and at 330 ft. spacing
- Access Frac<sup>®</sup> wells flowing back significantly stronger
- Access Frac<sup>®</sup> wells have slightly higher cumulative production

## Are We Dead Yet?



"Rumors of [our] Demise Have Been Greatly Exaggerated" – After Mark Twain