SOURCE ROCK:
The New Wave for Stimulation and Production

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Source Rock the new Wave

- We have been producing from Source Rock for many years but have just now started to learn how to economically produce the oil and Gas from these reservoirs.
- Common examples are the Devonian Shale in Appalachia and the Bakken Shale in the Rockies.
- With the use of “Waterfracs” and the success found in the Barnett Shale of North Texas, the industry is looking at Shale and Source Rock with a vastly different perspective than in the past.

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- Why the added emphasis now?

1. Success in the Barnett.
2. High oil and Gas prices.
3. Tremendous acceleration in learning curve of how to complete in unconventional rock.
4. Domestically we're running out of onshore conventional Reservoirs.

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- What's different in completion techniques?

1. Everything!
2. Typically, but not universally, because of the dominance of fractured permeability the wells must be completed horizontally.
3. The type of isolation mechanism depends upon the nature of the rock. Isolation of separate intervals is an absolute necessity to optimize stimulation and production.

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- What's different (cont)

4. Fracture design (They can be modeled)

   Everything that is sacrosanct in conventional design is open game in design of these treatments.

a. Large pad volumes with thin fluids.
b. Sweeps and over flushing are not only good but necessary.

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- What's different (cont.)

C Perforating "Geophysically"

D Perforating not based on lithology, porosity, crossover, etc etc.

E Proppant selection not based on proppant pack conductivity.

F Surfactants, as is the case in microdarcy rock, have been found to not be beneficial and in some cases detrimental.

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- "Waterfracs, or in some cases non-stabilized foam fracs have become the fluid of choice for treating the naturally fractured Source Rocks.
- Experience has shown that the use of conventional crosslinked gels is counter productive.

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- Complications of Source Rock Completions

1. Conventional completion mindset.
2. Perforations should be picked from FMI or other source of identifying natural fractures. Perforating using conventional procedures will result in pain and misery.
3. Tortuosity is really defined by perforating in the wrong place, in this case, in the matrix of the shale.

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- Complications of Source Rock Completions

4. The use of acid even in non reactive rock has been found to be extremely advantageous.
5. Diagnostics in the classic sense have been found to be very non-productive.
6. Not unlike Coal Seam Stimulation, once you have started pumping you do not want to shut down.

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- Complications of Source Rock Completions

7. Too aggressive pump-ins can doom the frac to failure.
8. Conventional monitoring of net pressure plots is counterproductive.
9. Building net pressure or not over flushing are not positive in the treatment of Source Rock.

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- Understanding the mechanism of stimulation of rocks which do not have a dominate stress

1. Obtaining a dominate fracture is counterproductive.
2. Proppant packs are also counterproductive.
3. Stimulation is achieved by bridging and diverting in a maze of fractures and the natural fractures are held open by the proppant yielding infinite conductivity.

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- Understanding the mechanism of stimulation of rocks which do not have a dominate stress (cont.)

4. The use of large proppants and even tailing in with large proppants has been counterproductive. Prior to the last 6 months, 40/70 has been the proppant of choice for waterfracs but recently there has been a move in the Barnett and Woodford shale to using very large volumes of 100 mesh as the primary proppant.
5. One very interesting finding is that where there appears to not be a dominate stress, the expected closure on proppant based upon fracture closure is not seen.

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- On Waterfrac Design

1. High rate is a necessity
2. Large volumes are required
3. We feel very strongly that proppant is required
4. The use of polymer at low concentration is essential when using high density proppant
5. Laboratory testing should be done to establish if surfactants are a positive or negative factor

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- On Waterfrac Design

6. Perforation placement and absolute control of fluid and proppant is essential. Concentrating energy into natural fracture systems is a key to success.
7. Pseudo Limited Entry is beneficial in most reservoirs

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- On Waterfrac Design

8. Sufficient pad should be pumped to put formation in a situation of stasis

- The use of spacers or “sweeps” is tremendously beneficial in achieving proper distribution of proppant as far as possible from the well bore
- We have not found a reservoir where surfactant was required---we feel that surfactants for the most part are detrimental in low permeability rock

Ely & Associates Recommendations & Comments Concerning "Water Fracs"

1. Use Large volumes and as much volume and concentration proppant water will carry.
2. Utilize 3D Frac models for design. The input data is correct!
3. Surfactants or lack thereof and KCl vs. KCl substitute are critical issues in Water Fracs.
4. The Water Frac technique properly applied has greatly increased the potential for producing Source Rock.
5. "Water Fracs" containing breaker and some proppant provide excellent refrac opportunities for applicable formations.

WELL / LOCATION
Michigan
FORMATION: Stacked Shale Sand sequence
Perforations 5,010-14, 5,034-38, 5,050-54, 5,062-66, 5,073-77
5,123-27, 5,133-37, 5,172-76 1 spf 32 .43" holes

Stage	Fluid Type	Fluid Volume (gals)	Proppant Concentration (ppg)	Stage Proppant (lbs)	Injection Rate (bpm)
1.	15 % HCL	2,000	-	-	10-70
2.	KCL Water + F.R.	85,000	-	-	70
3.	"	5,000	1 #/gal 100 mesh	5,000	70
4.	"	90,000			
5.	"	5,500	.1	550	70
6.	"	5,500	-	-	70
7.	"	5,500	.2	1,100	70
8.	"	5,500	-	-	70
9.	"	5,500	.4	2,200	70
10.	"	5,500	-	-	70
11.	"	5,500	.6	3,300	70
12.	"	5,500	-	-	70
13.	"	5,500	.8	4,400	70
14.	"	5,500	-	-	70
15.	"	5,500	1	5,500	70
16.	"	5,500	-		70
17.	"	5,500	1	5,500	70
18.	"	5,500	-		70
19.	"	5,500	1	5,500	70
20.	"	5,500	-		70
21.	"	5,500	1.25	6,875	70
22.	"	5,500	-		70

23.	“	5,500	1.25	6,875	70
24.	“	5,500	-	-	70
25.	“	5,500	1.25	6,875	70
26.	“	5,500	-	-	70
27.	“	5,500	1.5	8,250	70
28.	“	5,500	-	-	70
29.	“	5,500	1.5	8,250	70
30.	“	5,500	-	-	70
31.	“	5,500	1.5	8,250	70
32.	“	5,500	-	-	70
33.	“	5,500	1.75	9,625	70
34.	“	5,500	-	-	70
35.	“	5,500	1.75	9,625	70
36.	“	5,500	-	-	70
37.	“	5,500	1.75	9,625	70
38.	“	5,500	-	-	70
39.	“	5,500	2	11,000	70
40.	“	5,500	-	-	70
41.	“	5,500	2	11,000	70
42.	“	5,500	-	-	70
43.	“	5,500	2	11,000	70
44.	“	5,500	-	-	70
45.	“	5,500	2.25	12,375	70
46.	“	5,500	-	-	70
47.	“	5,500	2.25	12,375	70
48.	“	5,500	-	-	70
49.	“	5,500	2.25	12,375	70
50.	“	5,500	-	-	70
51.	“	5,500	2.5	13,750	70
52.	“	5,500	-	-	70
53.	“	5,500	2.5	13,750	70
54.	“	8,200	-	-	70

TOTALS: Fresh water - 500,000 gals. Plus tank bottoms*
40/70 Ottawa Sand - 199,925 lbs

- The additional water is for extending flush stages where we are seeing banking and or excess pressure.

DESIGN/FLUID CRITERIA:

1. Design Pump rate - 70 bpm.
2. Maximum Pump rate - 80 bpm.
3. Maximum treating pressure –3,800 psi.
4. HHP required 5,000 HHP plus 50% standby.
5. Fluid – Fresh water with friction reducer.
6. Based on pumping down 5,010’ of of 5 1/2” 15.5 # J-155 casing.
7. We will conduct a pump in to ascertain the number of perforations open.

ADDITIVES:
1. Fresh water only.
2. Water based friction reducer.
3. Check for emusion problems run NE if required.

ADDITIONAL EQUIPMENT:
1. 2 in-line densiometer(s).
2. Equipment to perform immediate flowback to closure while monitoring flowback rate and pressure.
3. Sand sieves, and associated equipment to perform QC on location. Sand sieves on all compartments and water analysis on all tanks.
4. 50 % Standby horsepower.
5. Pressure relief valve on the casing and kickouts or popoff required on downhole pumps.
6. Have ball gun on site and 48 low temperature bioballs for ballout if perforations are not all open.

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WELL / LOCATION: Texas
FORMATION: Northern Barnett Shale
PERFS: 7,931-34, 7,970-73, 8,000-03, 8,037-40, 8,085-88, 8,116-19, 8,160-63, 8,237-40, 8,270-73, 8,320-23, 8,348-51, 8,372-75, 8,396-99, 8,409-12 8,422-25, 8,455-58, 8,490-93, 8,510-13
1 spf 72 .43" holes

Stage	Fluid Type	Fluid Volume (gals)	Prop Conc (ppg)	Stage Prop (lbs)	Injection Rate (bpm)
1.	Water + F.R.	999,000	-	-	150
2.	"	10,000	.03	300	150
3.	"	10,000	-	-	150
4.	"	10,000	.04	400	150
5.	"	10,000	-	-	150
6.	"	10,000	.05	500	150
7.	"	10,000	-		150
8.	"	10,000	.06	600	150
9.	"	10,000	-	-	150
10.	"	10,000	.07	700	150
11.	"	10,000	-	-	150
12.	"	10,000	.08	800	150
13.	"	10,000	-	-	150
14.	"	10,000	.09	900	150
15.	"	10,000	-	-	150
16.	"	10,000	.1	1000	150
17.	"	10,000	-	-	150
18.	"	10,000	.12	1200	150
19.	"	10,000	-	-	150
20.	"	10,000	.14	1400	150
21.	"	10,000	-	-	150
22.	"	10,000	.16	1600	150
23.	"	10,000	-	-	150
24.	"	10,000	.18	1800	150
25.	"	10,000	-	-	150

26.	"	10,000	.2	2000	150
27.	"	10,000	-	-	150
28.	"	10,000	.22	2200	150
29.	"	10,000	-	-	150
30.	"	10,000	.24	2400	150
31.	"	10,000	-	-	150
32.	"	10,000	.25	2500	150
33.	"	10,000	-	-	150
34.	"	10,000	.25	2500	150
35.	"	10,000	-	-	150
36.	"	10,000	.25	2500	150
37.	"	10,000	-	-	150
38.	"	10,000	.5	5000	150
39.	"	10,000	-	-	150
40.	"	10,000	.5	5000	150
41.	"	10,000	-	-	150
42.	"	10,000	.5	5000	150
43.	"	10,000	-	-	150
44.	"	10,000	.75	7500	150
45.	"	10,000	-	-	150
46.	"	10,000	.75	7500	150
47.	"	10,000	-	-	150
48.	"	10,000	1	10000	150
49.	"	10,000	-	-	150
50.	"	10,000	1.25	12500	150
51.	"	10,000	-	-	150
52.	"	10,000	1.5	15,000	150
53.	"	10,000	-	-	150
54.	"	10,000	1.75	17,500	150
55.	"	10,000	-	-	150
56.	"	10,000	2	20,000	150
57.	"	10,000	-	-	150
58.	"	10,000	1.5	15,000	150
59.	"	10,000	-	-	150
60		10,000	1.5	15,000	150
61	"	10,000	-		150
62	"	10,000	2	20,000	150
63	"	15,000	-		150

TOTALS: Fresh water - 2,310,000 gals. Plus pit bottoms*

40/70 Ottawa	-	150,300 lbs
20/40 Ottawa	-	50,000 lbs

The additional water is for extending flush stages where we are seeing banking and or excess pressure.

- DESIGN/FLUID CRITERIA:

1. Design Pump rate - 150 bpm.
2. Maximum Pump rate - 180 bpm.
3. Maximum treating pressure –7,700 psi.
4. HHP required 28,000 HHP plus 50% standby.
5. Fluid – Fresh water with friction reducer
6. Based on pumping down 7,931' of of 5 1/2 " casing.

ADDITIVES:

1. Water based friction reducer.
2. Biocide.
3. Scale Inhibitor.

ADDITIONAL EQUIPMENT:

1. 2 in-line densiometer(s).
2. Equipment to perform immediate flowback to closure while monitoring flowback rate and pressure.
3. Sand sieves, and associated equipment to perform QC on location. Sand sieves on all compartments and water analysis on pit water.
4. 50% Standby horsepower.
5. Pressure relief valve on the casing and kickouts or popoff required on downhole pumps.
6. Have ball gun on site and 150 1.1 S.G. RCP balls for ballout if perforations are not all open.

TOTALS:	1 % KCL Water	-	740,000 gals. Plus tank bottoms*
	40/70 Bauxite **	-	208,500 lbs.
	100 Mesh sand	-	20,000 lbs.

DESIGN/FLUID CRITERIA:

1. Design Pump rate – 60 bpm.
2. Maximum Pump rate- 70 bpm.
3. Maximum treating pressure – 10,000 psi.
4. HHP required – 15,000 HHP plus 50% standby.
5. Fluid – 1 % KCL water + friction reducer.
6. All fluids should be Continuous mixed. Based on pumping down 14,642' of 5.5" Casing.

ADDITIVES:

1. 20 # Linear guar.
2. 1% KCl required for clay control-no KCl substitute.
3. Have 25% excess chemicals available for extra stages.
4. Have 39 full 500 barrel tanks of KCL or equivalent pit volume on location.
5. Utilize breaker for linear gel based on BHT of 259F.

*Additional KCL available for extra stages if required.
** or equivalent

ADDITIONAL EQUIPMENT:

1. 2 in-line densiometer(s).
2. Sand sieves, and associated equipment to perform QC on location. Sand sieves on all compartments and water analysis on all tanks.
3. 50% Standby horsepower.
4. Pressure relief valve on the casing and kick-outs or pop-off required on down hole pumps.
5. Have 60 medium temperature bioballs on location and ball gun if required. We will conduct an initial pump-in to evaluate holes open, tortuosity and leak off.

Source Rock the new Wave Conclusions

- “Water Fracs”, which have been in existence for a very long time have found a resurgence particularly in Source Rock and low permeability stacked pays.
- “Water Fracs”, properly designed have allowed us to economically stimulate and produce formations which heretofore were not economic even with ten dollar gas.
- There is a great deal of confusion in relation to proper design and implementation. We have made significant strides in this direction but a great deal remains to be learned.