#### SE Delaware Basin Slope: Debrites, Turbidites, Organics, Oh My!\*

#### Robert S. Nail<sup>1</sup>

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#### **Abstract**

The 2010 Wolfbone type completion of the Whiting Trainer Trust 16-2 well resulted in a 24-hour IP of 700+ BO, and a EUR of 188K+ BOE. This well initiated a comprehensive Whiting exploration program focused on the geologic province of SE Delaware Basin Slope strata. Whole core from several zones in the Brushy Canyon and Bone Spring formations was acquired from the Whiting Wolfpup 9604 well. Major lithofacies identified in core include carbonate debrite complex, carbonate and siliciclastic turbidite complex, organic-rich siltstone and shaly siltstone, med-crs siltstone, and mudstone. Except for mudstone, all lithofacies demonstrated mobile oil saturation with porosities ranging from 2-18%, and permeabilities from 100 nd to 5 µd. These major lithofacies are the result of primarily two distinctive physical processes comprised of large mass-transport deposits and pelagic deposits, dominantly controlled by slope failure, eustasy, detrital influx, and bottom currents. A modern depositional analogy is the northeastern Sicilian margin in the Tyrrhenian Sea (Gamberi et. al., 2010).

Two unconventional play concepts using stratigraphic relationships of lithofacies and presence of migrated and in situ oil and gas are presented. The first is the relationship between the second Bone Spring highstand carbonate debrite complex underlying the siliciclastic organic-rich 1st Bone Spring lowstand siltstone. The second is the siliciclastic organic-rich Pipeline Shale underlying a lowermost Brushy Canyon carbonate debrite complex in turn overlain by interlaminated carbonate and siliciclastic turbidites and pelagic organic-rich siltstone. Prior to and during evaluation of the core, several existing vertical wells were reentered and stimulated with a Wolfbone type completion, generally resulting in sub-economic results. Assuming an insufficient amount of rock could be stimulated from a vertical completion, it was decided to drill horizontal within "reservoir" debrite complex facies juxtaposed to "source" organic-rich siltstone. Three horizontal wells were drilled within the second Bone Spring debrite complex and two horizontal wells were drilled in the lowermost Brushy Canyon debrite complex. Four of the five wells resulted in significant initial production, followed by a relatively steep decline. All five wells were completed using open hole sliding sleeve ball technology. The next "knob to turn" is to complete using cased hole plug and perf technology.

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#### **References Cited**

Barba, Jr., R.E., and A.S. Cutia, 1992, Evaluating Horizontal Well Potential in the Spraberry Trend, Society of Petroleum Engineers, DOI: http://dx.doi.org/10.2118/23949-MS.

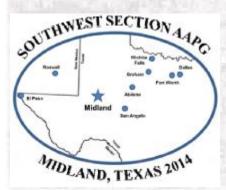
Gamberi, F., M. Rovere, and M. Marani, 2010, Modern Examples of Mass - Transport Complexes, Debrite and Turbidite Associations: Geometry, Stratigraphic Relationships and Implications for Hydrocarbon Trap Development: AAPG Annual Convention and Exhibition, New Orleans, Louisiana, April 11-14, 2010. Web Accessed July 1, 2014. http://www.searchanddiscovery.com/pdfz/documents/2010/40536gamberi/ndx\_gamberi.pdf.html.

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May 13, 2014





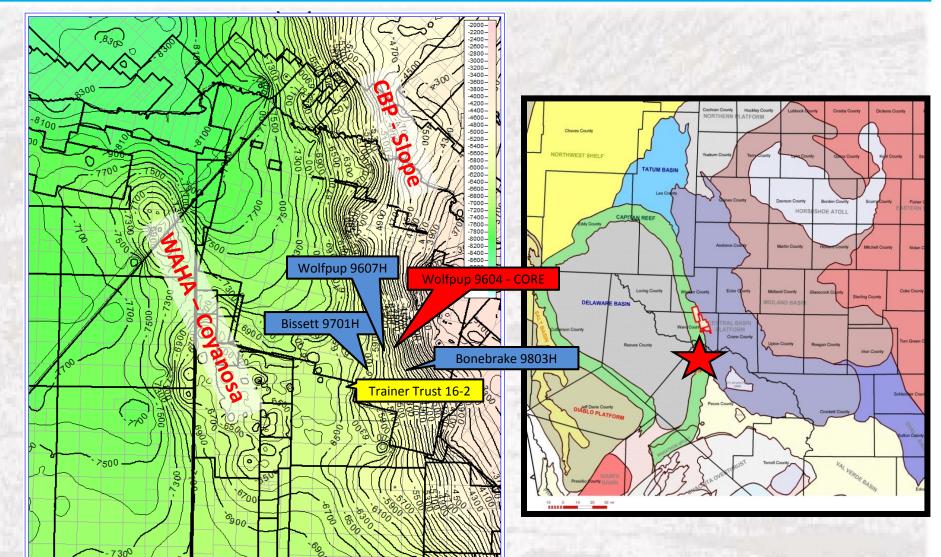
# Agenda



- SE Delaware Basin Slope
- Stratigraphy / Type Log
- Wolfbone Vertical Completions
- Exploration Data / Considerations
  - Geochem
  - Core
- Depositional Model and Modern Analogue
- 2<sup>nd</sup> Bone Spring (BSPG) Slope Play
- Conclusions / Recommendations

### **SE Delaware Basin Slope (Pecos County)**





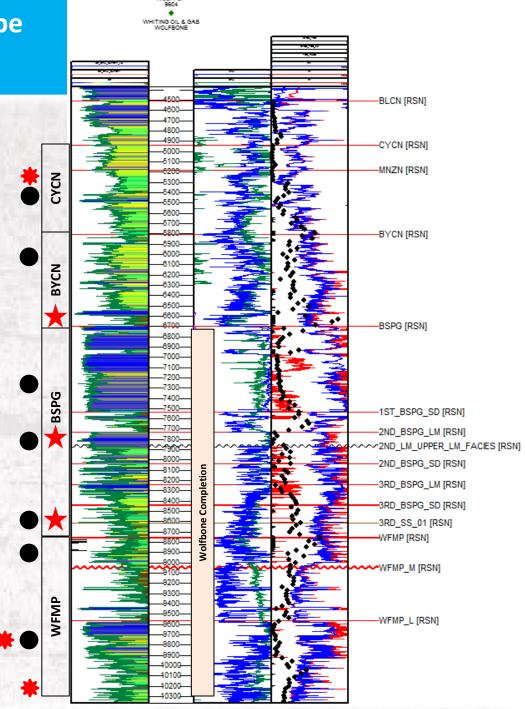


- Type Log Wolfpup 9604 (Mid-Slope)
  - Track 1 GR
  - Track 2 N/D
  - Track 3 Resistivity and TOC (0-5%, 30' Cuttings)
- All Formations produce oil and/or gas (Ro range 0.6 – 1.2)
- Cherry Canyon
- Brushy Canyon
- Bone Spring
- Upper Wolfcamp
- Lower Wolfcamp



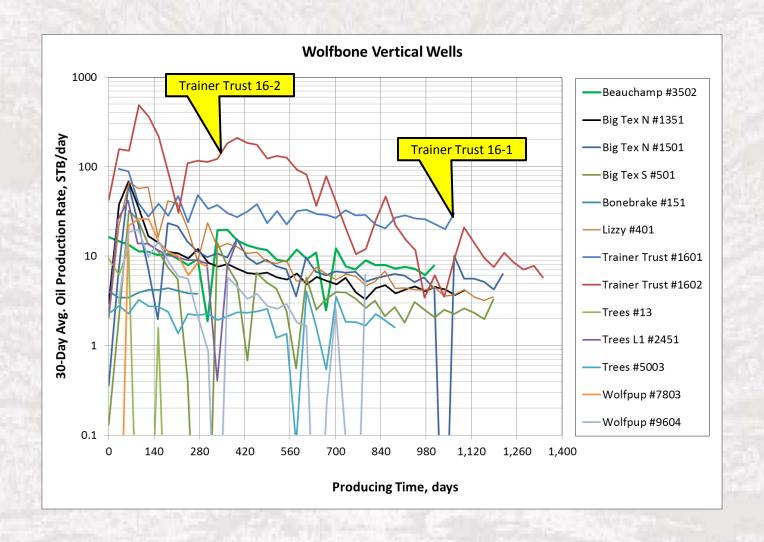
# Gas

Oil



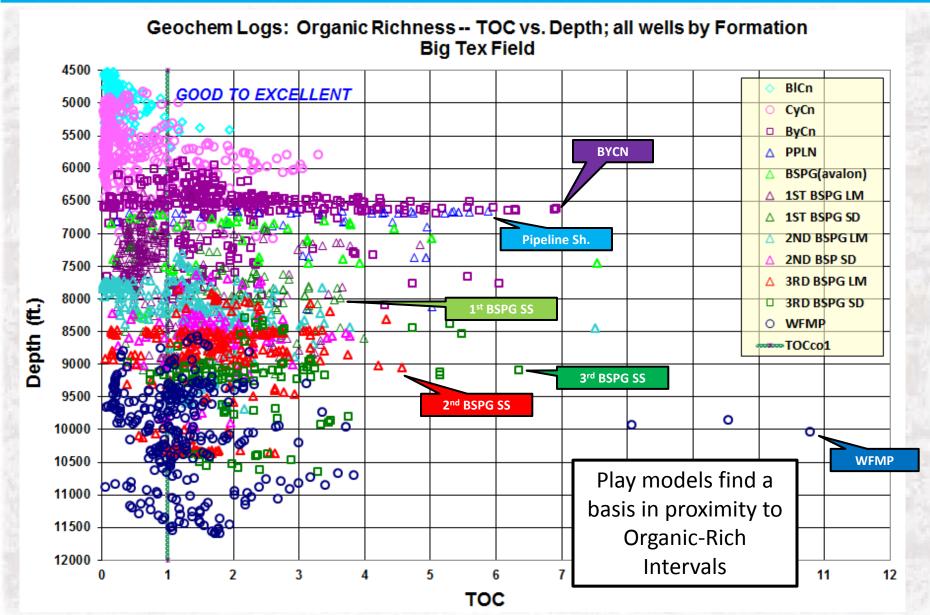
# **Vertical Wolfbone Completions**





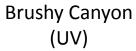
### One Tool for Evaluating 6000'+ of Strat

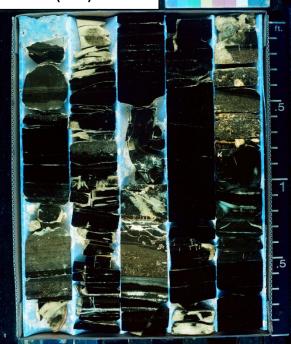




## Wolfpup 9604 Core



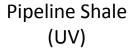


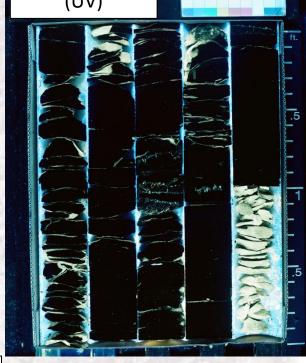




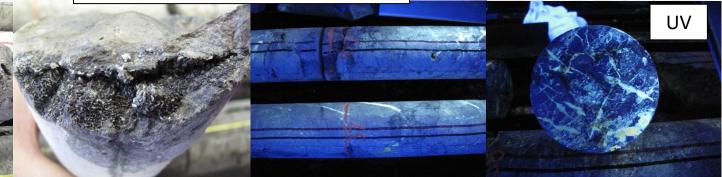
All Looks Good! Hydrocarbons, porosity, some perm, fractures, source, reservoir

2<sup>nd</sup> Bone Spring Limestone Member





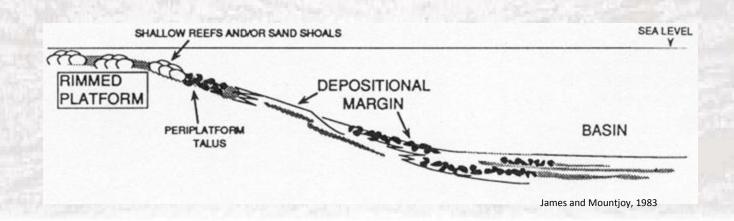




## Slope Morphology & Depositional Style



- Paleogeography, depositional environments, and resulting lithofacies are similar throughout the entire succession of lower Brushy Canyon-Pipeline-Cutoff-Bone Spring Fm.-Wolfcamp
- Slope-toe of Slope transition with gross interbeds of insitu fine slope silt/mud and transported thin (mm to 1m scale) turbidites (high density) and thicker (1+ meter scale) debris flow complexes (debrites)
- These major lithofacies are the result of primarily two distinctive physical processes comprised of large mass-transport deposits and pelagic deposits, dominantly controlled by slope failure, eustasy, detrital influx, and bottom currents.
- Occurrence and stratigraphic placement of transported flows varies locally (Chaotic Slope), which can cause correlation constipation!



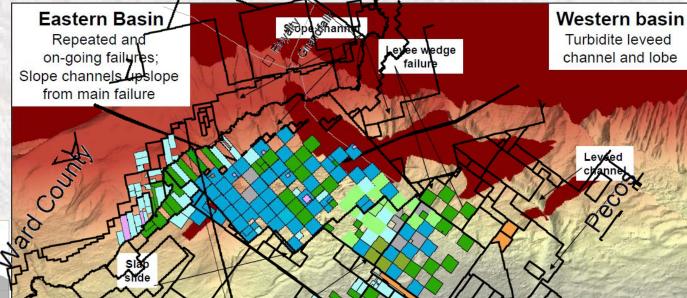
#### Modern Depositional Analogue for SE Delaware Basin



Distributary channels

SoutheasternTyrrhenian Sea

 Debrite-Turbidite relationships



Sardinia

Warsill basin plain

Stromboli Valley

Stromboli Valley

Stromboli Valley

Sun AZMETHEWA 45

Basin

10'

12'

14'

16'

Transpressional margin Of main landslide

Debris

(modern analogue provided by Fabiano Gamberi, Marzia Rovere, Michael MaranilSMAR-CNR, Rologna Italy. AAPG Annual Convention, 2010)

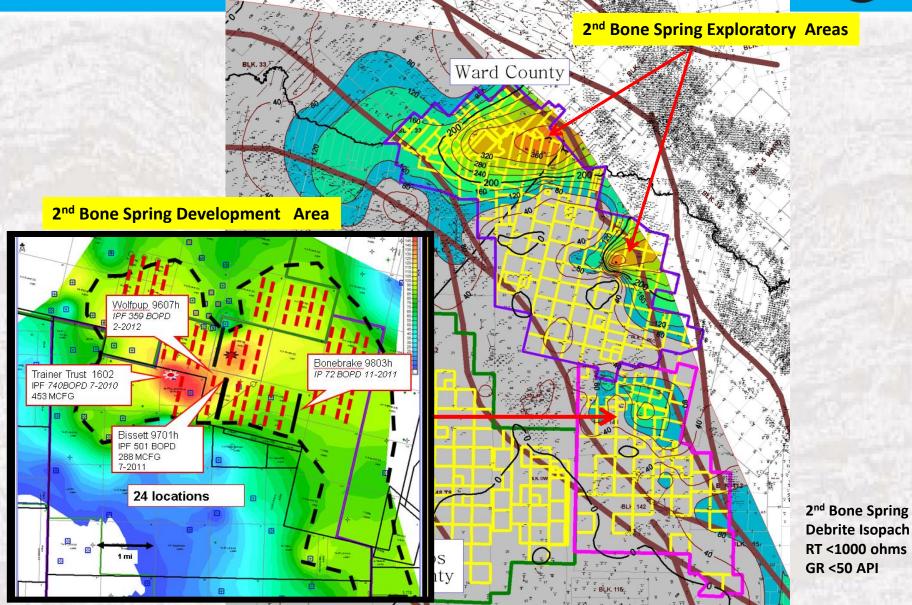


Play Focus: 2<sup>nd</sup> Bone Spring (BSPG)

# PLAYS AND REPRESENTATIVE DATA

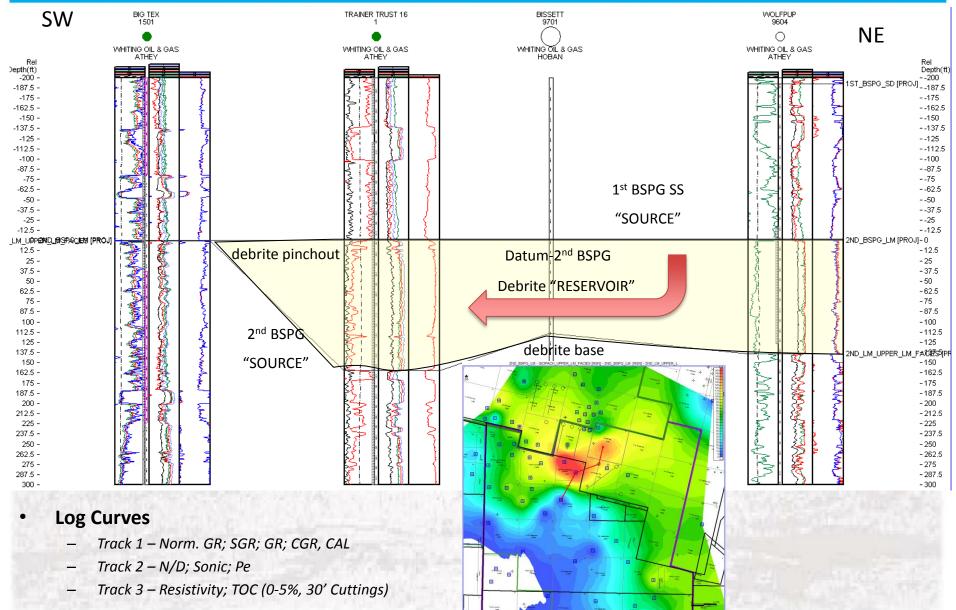
# 2<sup>nd</sup> BSPG Debrite Prospectivity





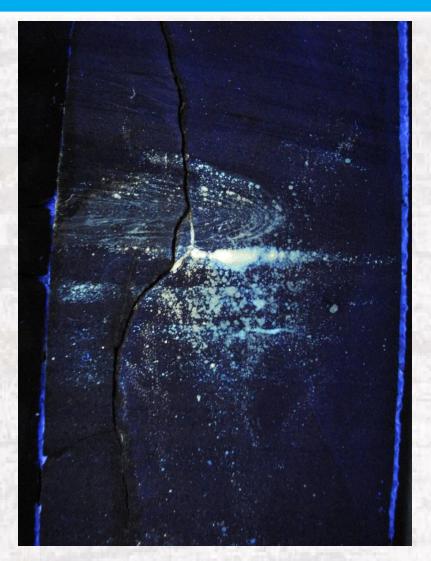
### 2<sup>nd</sup> BSPG Limestone Target - Bissett 9701H





# Base of 1st BSPG Sandstone



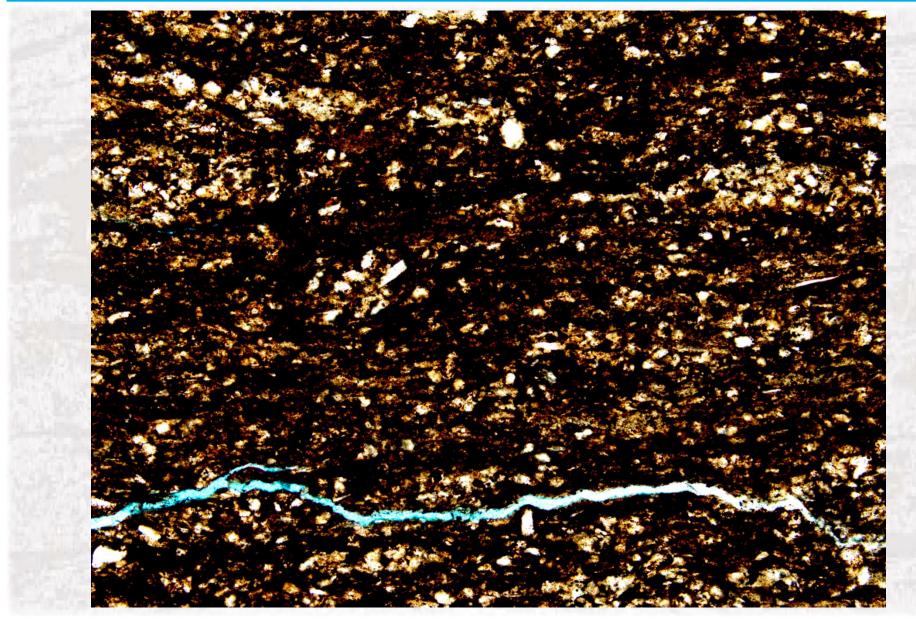




Soft sediment deformation slump within thin interbedded grainstone and organic rich siltstone laminations (UV on left, WL on right). Gil B. suggested I may have a new giant fusulinid, *Gigantuana species*?

# Base of 1st BSPG Sandstone

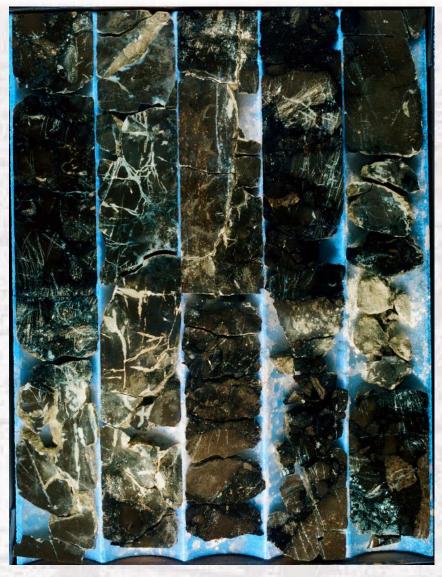




# 2<sup>nd</sup> BSPG Debrite



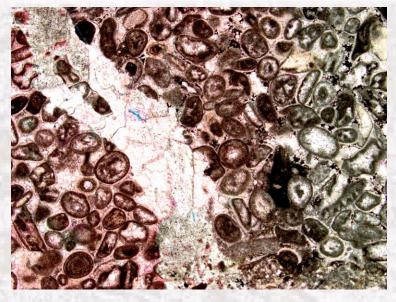




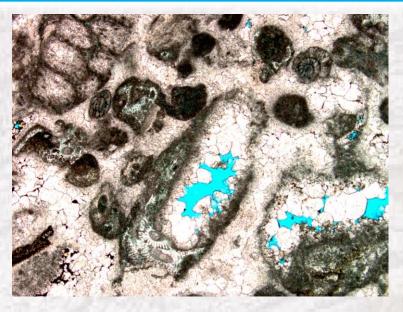
Extensive oil-filled fractures with multiple cross-cutting episodes. Variable intraclast flourescence due to facies.

# 2<sup>nd</sup> BSPG Debrite











## 2<sup>nd</sup> BSPG Debrite



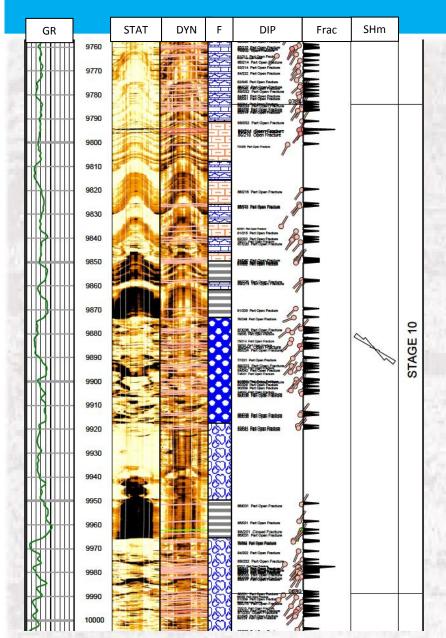
- Major clast facies peloid, miliolina (foram), bryozoa grainstone. GR (~5-10 api) and resistivity (~300 ohhm) less relative to rest of 2<sup>nd</sup> BSPG LM debrite interval.
- Oil fluorescence from a combination of porous fracture and matrix from various clasts (90' from top of 2<sup>nd</sup> BSPG LM); variability associated with intraclast porosity. Grainstone to the left (7809.8') and mudstone on the right (7814.4); fractures throughout.

DEPTH	GRAIN	POR	PERM	SATUR	ATIONS	FLU	ORESCENCE
ft	DENSITY	%	mD	Sw	So	%	DESCR
7789.9	2.7	1.3	tbfa	28.3	3.6	10	Brt yl-blu-wht
7795.1	2.71	1.6	0.113	28.7	0.01	10	Brt yl-wht
7802.6	2.71	8.6	0.286	13.1	17.8	100	Brt yl-blu-wht
7804.6	2.71	3.5	0.001	13.5	17.3	80	Brt yl-blu-wht
7806.1	2.7	4.4	0.013	15.6	18.1	100	Brt yl-blu-wht
7808.1	2.7	3.5	0.001	13.2	18.9	80	Brt yl-blu-wht
7809.8	2.7	6.2	0.023	21.5	19.5	80	Brt yl-blu-wht
7812.2	2.7	3.6	0.001	11.7	14.2	100	Brt yl-blu-wht
7814.4	2.7	1.8	0.001	28.2	0.01	10	Brt yl-blu-wht
7815.4	2.71	5	tbfa	14.5	13.6	70	Brt yl-bl-wht
7815.6	2.71	5.1	0.03	14.2	15.5	80	Brt yl-bl-wht



#### Bissett 9701H – 2<sup>nd</sup> BSPG Open Hole Sliding Sleeve Completion





Scheduled 18 stage frac with 3,052 bbls 25# frac fluid, 24 bbls 7.5% HCl, 50,000 #'s 20/40 White sand, and 50,000 #'s 20/40 Super LC sand per stage.

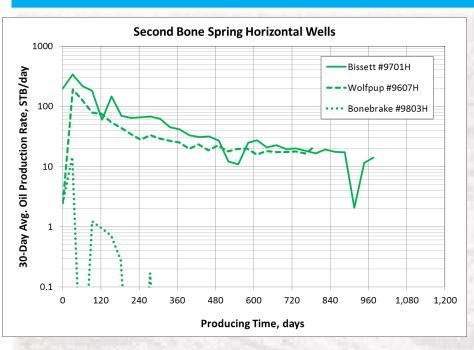
Total fluid pumped was 35,089 bbls and 1,421,027 #'s sand.

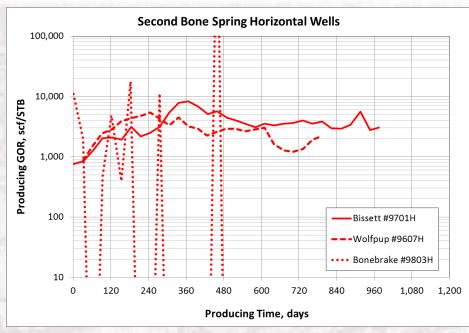
Surface treating pressure range 3800-7300 psi with rate range 57-71 bpm. Stages 12 and 14 sleeve would not open, no volumes pumped. Stages 16, 17, and 18 reduced volumes due to max pressure.

STAGE	FRACTURE COUNT	FRACTURE DENS	FRACTURE SPACING
	#/STAGE	#/GROSS INT	FT
STAGE 1	27	0.14	6.94
STAGE 2	13	0.06	15.77
STAGE 3	18	0.09	11.41
STAGE 4	15	0.07	13.6
STAGE 5	39	0.19	5.24
STAGE 6	20	0.1	10.24
STAGE 7	28	0.14	7.32
STAGE 8	54	0.26	3.79
STAGE 9	68	0.33	3
STAGE 10	67	0.33	3.06
STAGE 11	82	0.4	2.49
STAGE 12	76	0.37	2.68
STAGE 13	95	0.46	2.16
STAGE 14	153	0.76	1.32
STAGE 15	91	0.45	2.24
STAGE 16	35	0.17	5.86
STAGE 17	47	0.23	4.3
STAGE 18	31	0.16	6.22

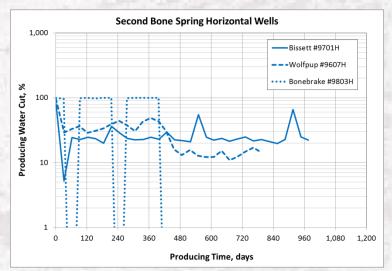
### 2<sup>nd</sup> BSPG Horizontal Production







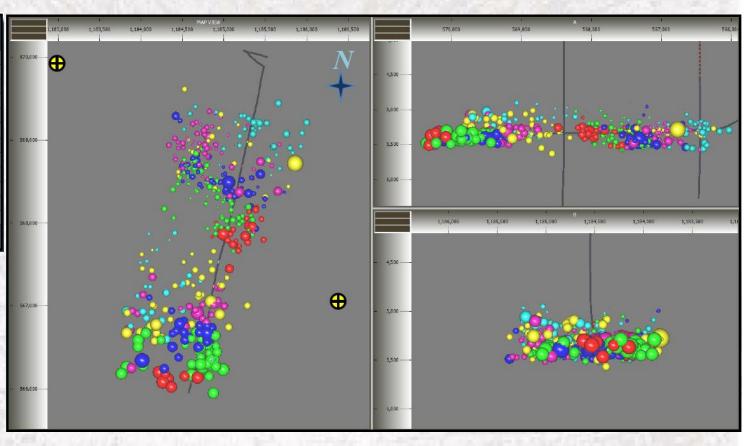
	Cum Oil MSTB	Cum Gas MMscf
Bissett 9701H	59.5	148.2
Wolfpup 9607H	30.8	76.7
Bonebrake 9803H	0.6	4.3



# Wolfpup 9607H Microseis



Stage	Imaged Events
1	7
2	40
3	20
4	23
5	39
6	28
7	23
8	76
9	51
10	61
11	26
12	41
Total:	435

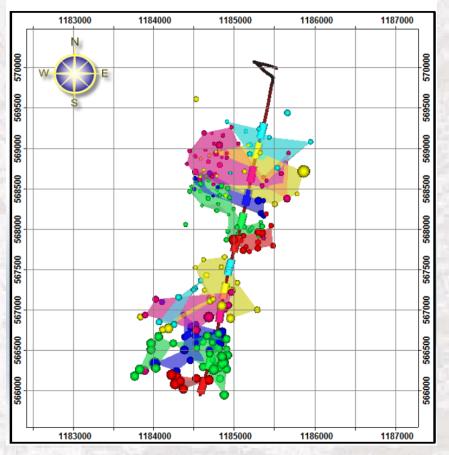


# Wolfpup 9607H Microseis



M-SRV by Stage					
Stage	"Gross"	"Net"	%		
	MMft <sup>3</sup>	MMft <sup>3</sup>			
1	1.2	1.2	100%		
2	24.6	16.6	67%		
3	11.2	8.8	78%		
4	46.6	7.3	16%		
5	85.7	11.8	14%		
6	53.9	1.3	2%		
7	10.4	2.4	23%		
8	65.9	6.7	10%		
9	56.8	3.6	6%		
10	74.3	19.8	27%		
11	22.6	11.0	49%		
12	38.8	4.0	10%		
Total:	492.2	94.7	19%		

#### By-Stage Net M-SRV (scales in ft)

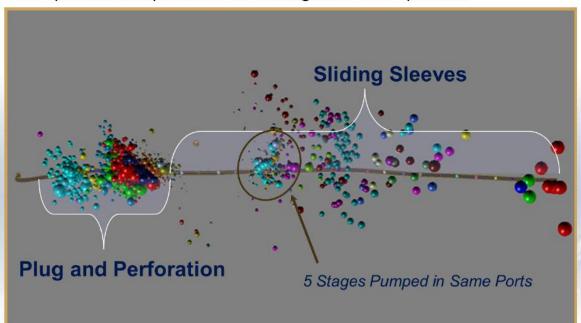


### SS vs. PP Microseis



#### **Post-Stimulation Evaluation**

Sliding Sleeve versus Plug and Perforate. The figure below shows the microseismic response of the stimulation of Whiting's Well (Sanish, Williston Basin). This operation had 30 stages using two completion technologies: (1) ball-actuated sliding sleeve (Stages 1-21) and (2) plug and perforated (uncemented casing using open-hole packers for stage isolation - Stages 22-30). The figure is a map view showing a stronger microseismic response for the plug and perforation completion compared to the sliding sleeve completion.



#### **Conclusions**



#### SE Delaware Basin Slope Is Prospective

- Multiple Unique and New Play Types
- Primary geologic challenges include stratigraphic and fracture/fault relationships (seismic needed)
- Primary engineering challenges include proper stimulation technique and recipe (PP, slick water?)
- Permian Play Analogy Spraberry Horizontals
  - 1987: ARCO, Exxon, Mobil Drain Hole concept (Texas Monthly August 1987)
  - 1992: "Eight attempts.....results have been disappointing to date. The model predictions......used to help predict the optimum completion...." (Barba, et.al., SPE, 1992)
  - 2014: Early production data suggests EUR's ....will be 575 MBOE to 800 MBOE (Pioneer Natural Resources Investor Presentation April 2014)

### Old Basins, New Ideas



We really are living in the science fiction world. All of the amazing technology that we had on Star Trek, that was supposed to be the future. For example, we walked all around the starship with this incredible device attached to our hip. Whenever we wanted to talk with someone, we would rip that off, flip it open and start talking. Astounding! No cords attached to it.

Today, in our lives, that amazing science fiction device has become a real nuisance in our world. It takes pictures, we make restaurant reservations. We buy movie tickets. It's an amazing device, and we are now in that science fiction world.

I think Gene Roddenberry, who created Star Trek, was a change agent because, with his imagination, he visualized the future and made that a goal, a benchmark. *And other change agents, like the inventors, the engineers, the scientists, the technicians, took that as a goal to strive for, and they with their genius, made that a reality. "OH MY!"* 



George Takei, aka Sulu