



Society of Petroleum Engineers
**Annual Technical
Conference and Exhibition**

26-28 September 2016
DUBAI WORLD TRADE CENTRE
Dubai, UAE

SPE-181658-MS

**Mississippi Canyon Gulf of Mexico Frac Pack Case Histories
and the Importance of Proppant Tracing and Gravel Pack Logging**

Jack Sanford, SPE



Society of Petroleum Engineers

Agenda

➤ Introduction

- Case History Summary
- Location
- Why are they Important?

➤ Objectives

➤ What are Tracers & Gravel Pack Logs?

➤ Results

- The Reverse Out: Santa Cruz - MC 519 Well 1
- The Void: Big Bend - MC 698 Well 1
- The Releasing Packer: Dantzler – MC 782 Well 2

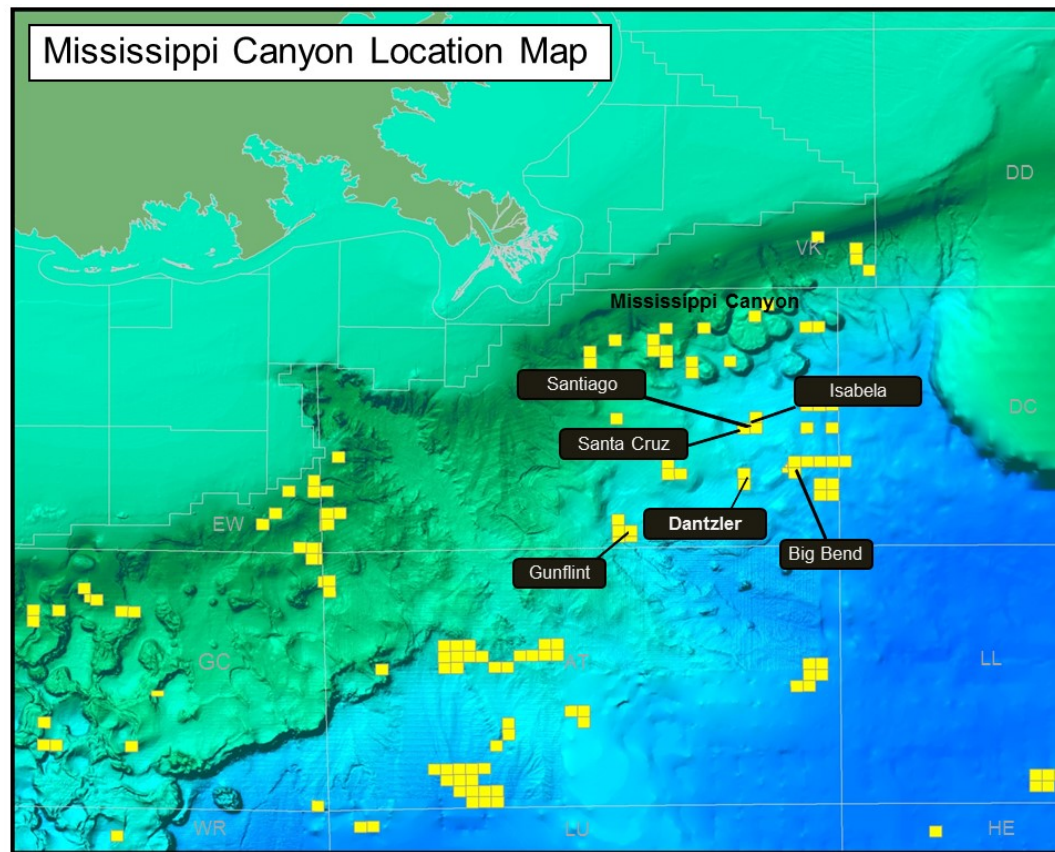
➤ Conclusions

➤ Acknowledgements / Questions

Case History Summary

Metric	Unit	Value
Fields		6
Wells		8
Logs Evaluated		17
Log Conveyance Methods		3
Disasters Adverted		3
Pumping Companies		3
Hardware Companies		4
Cumulative Production	MMBOE	70
Cumulative Initial Production Rate	MBOEPD	225
Current Production Rate	MBOED	90
Average Initial Rate	MBOED	18
Average Skin		5.0
Average PI	Bbl/psi/d	22.0
Max Depth	ft-MD	27,000
Max Pressure	psi	18,700
Max Fluid Density	ppg	14.2

Locations



Importance

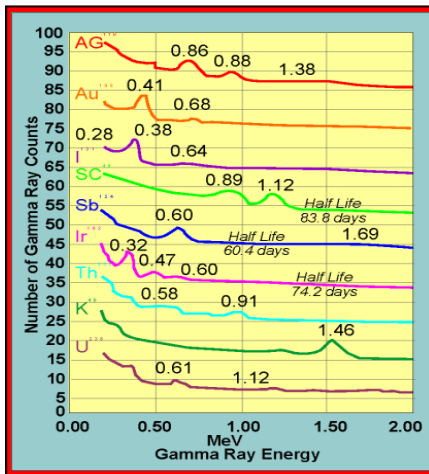
Well #	Well Name	Block Well Number	Reservoir	Water Depth (ft)	Completion Depth (ft-TVD)	Angle thru Perfs (Deg)	Net Pay (ft)	Transmissibility (md-ft/cp)	Initial Pressure (psi)
1	Santa Cruz	MC 519 #1	M55	6616	18,743	17	49	46,994	12,200
			M56L		18,231	17	78	166,230	11,893
2	Isabela	MC 562 #1	M55	6435	18,792	25	92	58,723	12,203
3	Santiago	MC 519 #2	M55	6500	18,474	0	61	52,835	12,105
4	Big Bend	MC 698 #1	M55	7221	15,458	20	124	116,824	8,180
5	Dantzler	MC 782 #1	U5	6565	17,367	0	80	914,286	10,500
			U6		16,745	0	41	50,919	10,204
6	Dantzler	MC 782 #2	U5	6569	17,430	18	75	45,095	10,562
			U6		16,806	18	47	25,097	10,218
7	Gunflint	MC 948 #4	Blue E	6094	26,653	10	124	37,576	18,692
8	Gunflint	MC 948 #2	Green B	6095	24,175	20	107	69,783	17,469
			Green C		24,312	20	67	49,894	17,431

Objectives – Tracers & GP Logs

- Prove gravel pack integrity
 - Evaluate Formation Frac Efficiency (Coverage and Placement)
 - Identify Annular Pack (Competency, Completeness, Reserve)
 - Confirm Completion Hardware (Performance and Placement)
- Assist in reservoir performance evaluation.
- Help guide start-up procedures
- Serve as reference information
- Creating best practices in FP and completion designs.

What are Tracers & Gravel Pack Logs

Tracers



Injected into Proppant

Iridium 192: (Ir, 74-day half-life)

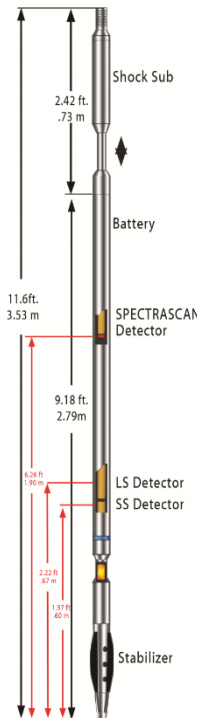
Scandium 46: (Sc, 84-day half-life)

Other Available:

Antimony 124*: (Sb, 60-day half-life)

*Not approved for use offshore.

GP Logs



Spectral Gamma Ray Annular Pack Density

Memory Data:

- Downloaded when the tool arrives at the surface.
- All gamma ray readings vs time data is retrieved from the tool's memory
- SGR: Merged with washpipe depth vs time data from an optical depth encoder system (captured on rig floor).
- APD: Merged with completion hardware schematic to identify changes in hardware, casing diameter and casing thickness.
- Result: Gamma ray vs depth data is computer processed into the spectral gamma ray log & Annular Pack Density log. Noble's preferred graphic has six(6) tracks.

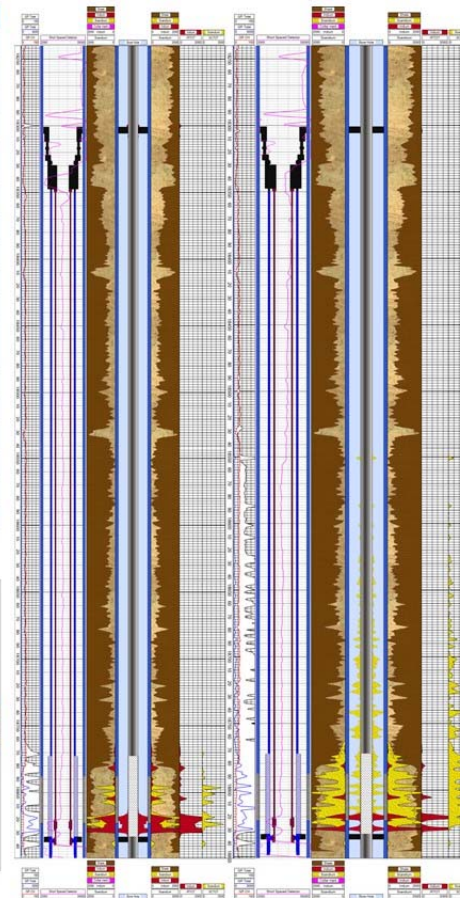
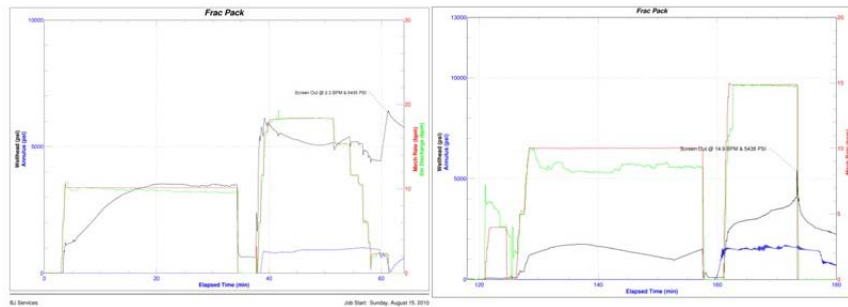
A fully packed annulus will register a higher bulk density (lower counts) than an annulus containing voids, assuming the same fluid density and have high spectral gamma ray counts from the proppant.

High Level Result Summary

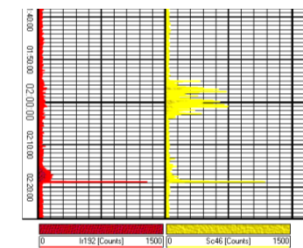
- Eliminated three(3) potential “Trainwrecks” : Delayed Production and > 60-MM\$
 - The Reverse Out: Santa Cruz
 - The Void: Big Bend
 - The Releasing Packer: Dantzler 2
- Modified two (2) different tool designs

The Reverse Out: Santa Cruz – MC 519 Well 1

Well		Santa Cruz	Santa Cruz
Log Number		1	2
Date		08/17/2010	08/22/2010
Zone		M55	M55
Log Conveyance		Electric Line	Electric Line
Annular Pack		No Pack – Rev Out Bottom 10-ft Only	Complete - No Voids
Fracture		Contained in Reservoir	Contained in Reservoir
Tip Screen-out		Yes	Yes
Net Pressure	psi	326	1986
Proppant Placement	#/ft	1629	799
Second Tracer Stage (Iridium)	10-ppa	To Bottom Perf	Entire Interval
Good Annular Proppant Reserves		None 50-ft of Screen Exposed	Yes – Good
Top of Sand (TOS) identified by both logs		Consistent	Consistent
Blank Coverage	ft	0	270
Completion Hardware		Identified Correctly	Identified Correctly
Productivity Index (PI)	Bbl/psi/d	NA	15.3
Initial Rate	boepd	NA	13000
Skin		NA	8.1

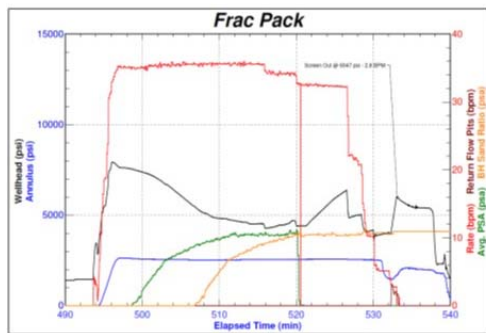


STMU

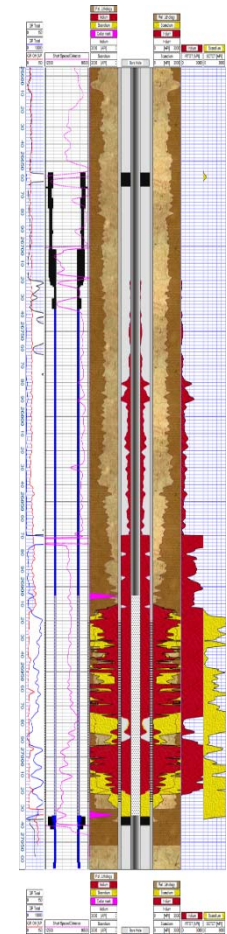
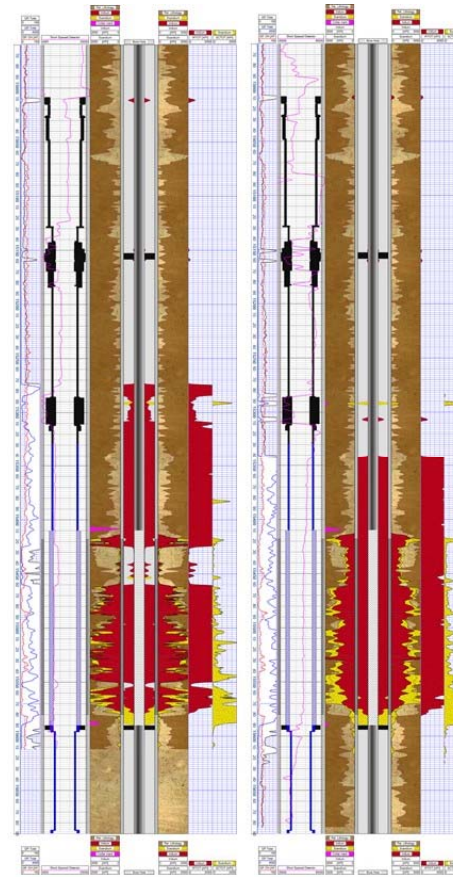


The Void: Big Bend – MC 698 Well 1

Well		Big Bend	Big Bend
Log Number		1	2
Date		02/25/2014	03/07/2014
Zone		M55	M55
Log Conveyance		Wash Pipe	Slick line
Annular Pack		Questionable Pack 36-ft Void Btwn Top 2 Lobes	Complete Pack No Voids Gravity Works
Fracture		Contained in Reservoir	Contained in Reservoir
Tip Screen-out		Yes	Yes
Net Pressure	psi	147	NA
Proppant Placement	#/ft	1091	NA
Second Tracer Stage (Iridium)	8-ppa	To Bottom Perf	To Bottom Perf
Good Annular Proppant Reserves		Yes	Yes – Good
Top of Sand (TOS) identified by both logs		Consistent	Consistent
Blank Coverage	ft	130	70
Completion Hardware		Identified Correctly	Identified Correctly
Productivity Index (PI)		NA	45.2
Initial Rate	boepd	NA	23000
Skin		NA	4.5

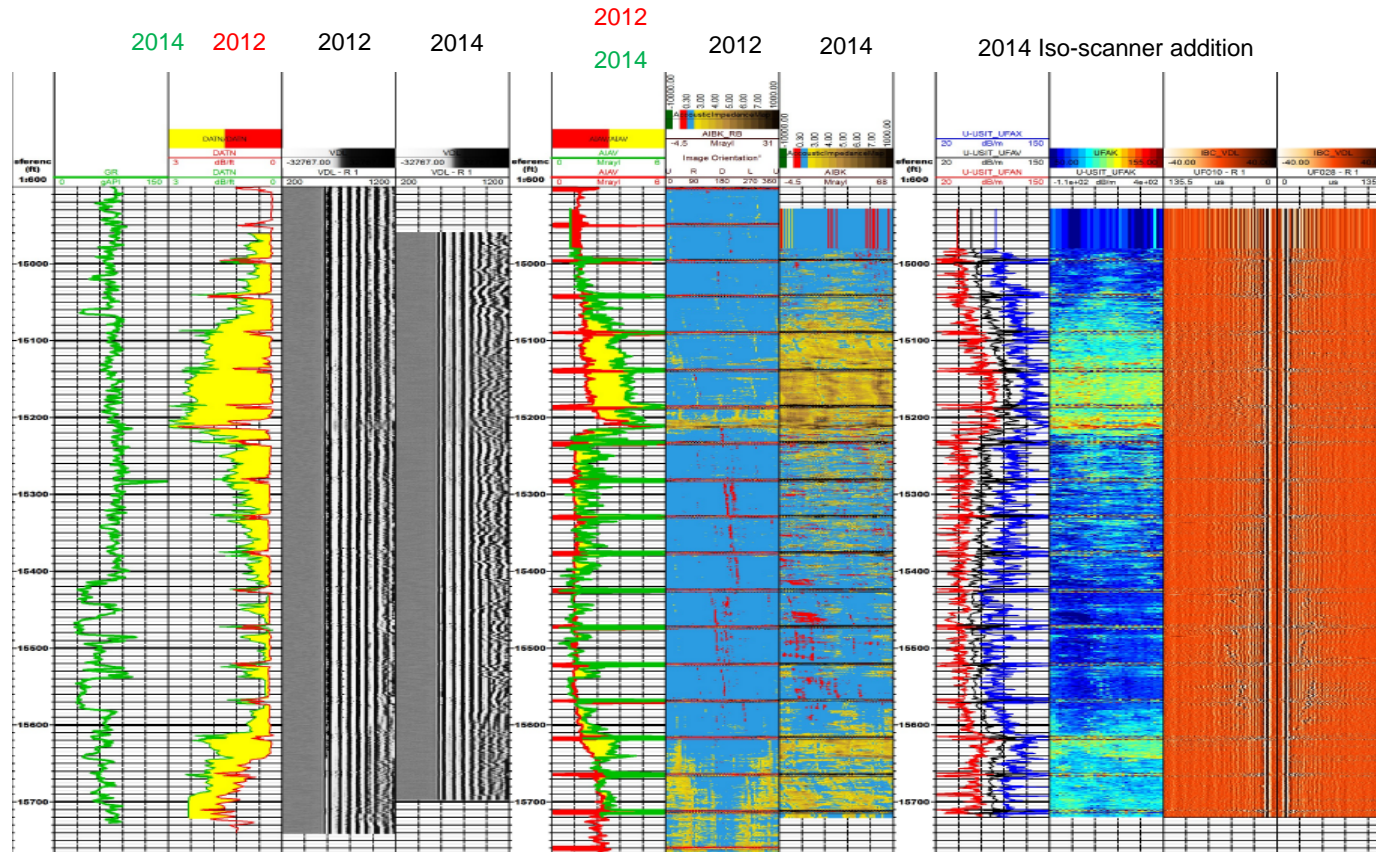


Society of Petroleum Engineers
Annual Technical Conference and Exhibition



Gunflint 4

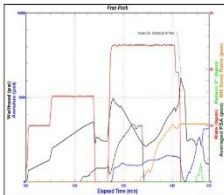
Big Bend - Acoustic Log Comparison: 2012 vs 2014 repeat



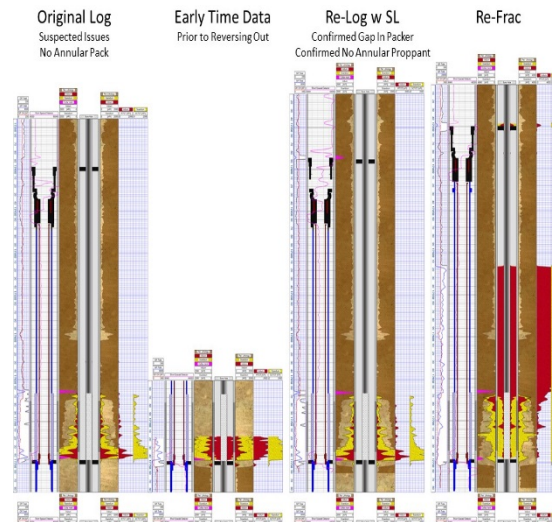
The Releasing Packer: Dantzler – MC 782 Well 2

Initial FP

Well	Dantzler 2	Dantzler 2
Log Number	1	2 Re-Eval Early Data
Date	02/25/2014	03/07/2014
Zone	U5	U5
Log Conveyance	Wash Pipe	Prior to Rev Out Early Data
Annular Pack	No Pack	?
Fracture	Contained in Reservoir	?
Tip Screen-out	Yes	Yes
Net Pressure	psi	700
Proppant Placement	#/ft	892
Second Tracer Stage (Iridium)	8-ppa	To Bottom Perf
Good Annular Proppant Reserves	Yes	?
Top of Sand (TOS) identified by both logs	Consistent	NA
Blank Coverage	ft	0
Completion Hardware	Questionable	?
Productivity Index (PI)	NA	NA
Initial Rate	boepd	NA
Skin	NA	NA

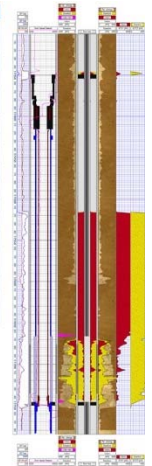
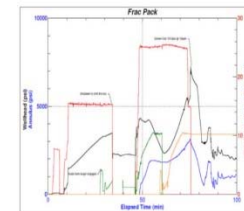


GP Log Progression



2nd FP

Well	Dantzler 2	Dantzler 2
Log Number	3	4
Date	02/25/2014	03/07/2014
Zone	U5 - ReLog	U5 - Refrac
Log Conveyance	Sickline	Wash Pipe
Annular Pack	No Pack	Complete Pack
Fracture	Reversed Out	No Voids
Tip Screen-out	Contained in Reservoir	Contained in Reservoir
Net Pressure	psi	NA
Proppant Placement	#/ft	1360
Second Tracer Stage (Iridium)	8-ppa	To Bottom Perf
Good Annular Proppant Reserves	Yes	Yes - Good
Top of Sand (TOS) identified by both logs	Consistent	Consistent
Blank Coverage	ft	0
Completion Hardware	Packer Moved Up-hole 11-ft	Identified Correctly
Productivity Index (PI)	NA	17.1
Initial Rate	boepd	25000
Skin	NA	5.1



Conclusions

- **Proppant tracing and gravel pack logging is an essential diagnostic tool that can be used to assess:**
 - Mechanical and gravel pack (annular) integrity of a sand control installation.
 - Actual proppant placement versus the design of a fracture stimulation treatment.
- **Without the use of these tools at least three (3) of the case history wells would have been left in a compromised position which could have resulted in a sand control and/or well failure.**
- **Noble Energy's success in the Mississippi Canyon area could not have been possible without tracing and gravel pack logging.**

Acknowledgements / Thank You / Questions

Tim Hopper, SPE:	Noble Energy
Josh Fink, SPE:	Noble Energy
Buddy Woodruff, SPE:	Protechnics Division of CoreLab
Alex Darnley, SPE:	Protechnics Division of CoreLab
Marc Peacher, SPE :	Protechnics Division of CoreLab

