A Case Study into the Successful Evaluation and Completion Non-conventional Wells in Mexico

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Presentation Outline

- NUTECH experience in the Eagle Ford and Burgos Basins
- How NUTECH's unconventional analysis process is used in new shale plays
- Highlight similarities and differences between the Eagle Ford, Haynesville and La Pimienta formations
- Tangram and Céfiro examples – Petrophysical analysis, geomechanical modeling and completion design considerations
- Well performance and lessons learned
- Moving forward in La Pimienta and Eagle Ford

NUTECH Timeline

1998
NULOOK PETROPHYSICS
Determine bound water fraction and permeability

2002
NULOOK
Determine pore size and texture

2003
NUSTIM COMPLETION ENGINEERING
Multi-scenario stimulation optimization

2003
NULOOK
Method of determining TOC, porosity and permeability of organic shales

2005
NUVIEW
Texture based reservoir mapping

2006
NUSTIM
Diagnostic Fracture Injection Test Analysis

2006
NULOOK
Utilize multiple triple combo data fracture indicators to identify frequency of natural fractures

2006
NULOOK
Inflection points are utilized to increase vertical resolution in low contrast/highly laminated intervals thru binary logic

2008
NUSTIM
Geomechanical properties log

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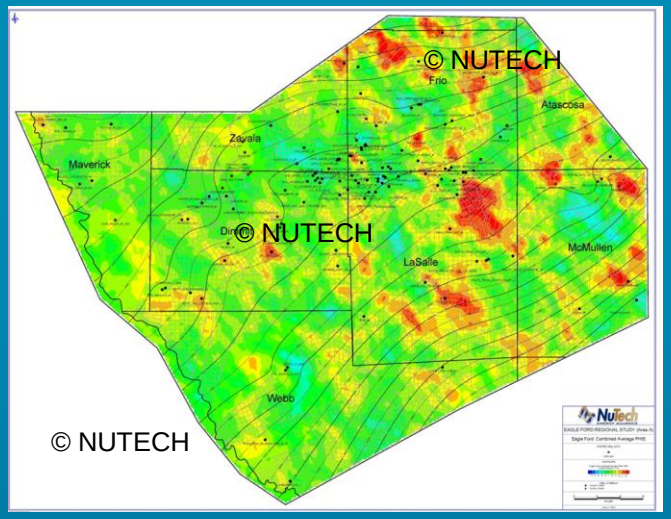
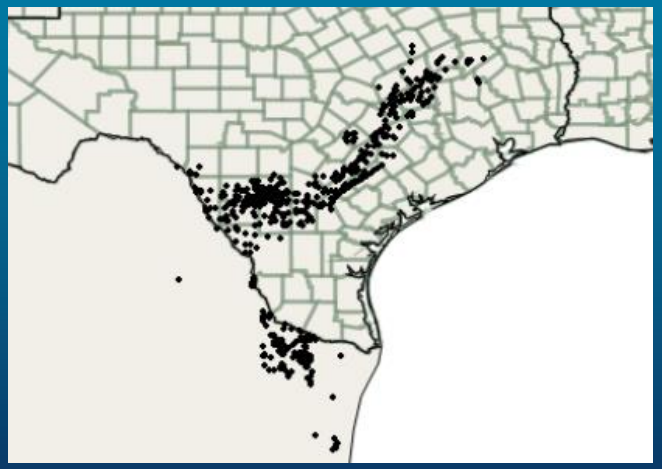
NUTECH Experience in the Eagle Ford and Burgos Basins

- Field Studies developed with publically available data since 2009
- Over 2000 wells evaluated and over 500 completions designed for operators



© NUTECH - Effective Porosity Map Eagle Ford

- Over 1000 wells evaluated in the Burgos basin with conventional and tight gas targets since 2004
- Eagle Ford analog analysis
- Analysis and completion design of 8 new wells in the Eagle Ford and 2 new wells in La Pimienta



Evaluated well sample - NUTECH

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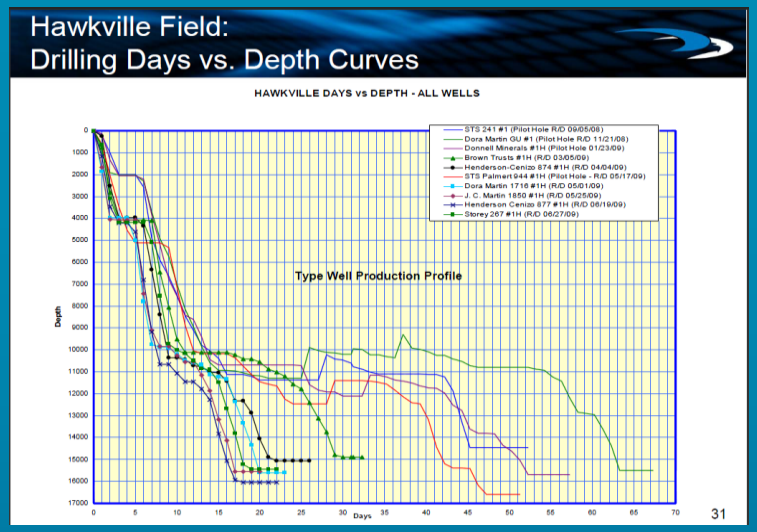
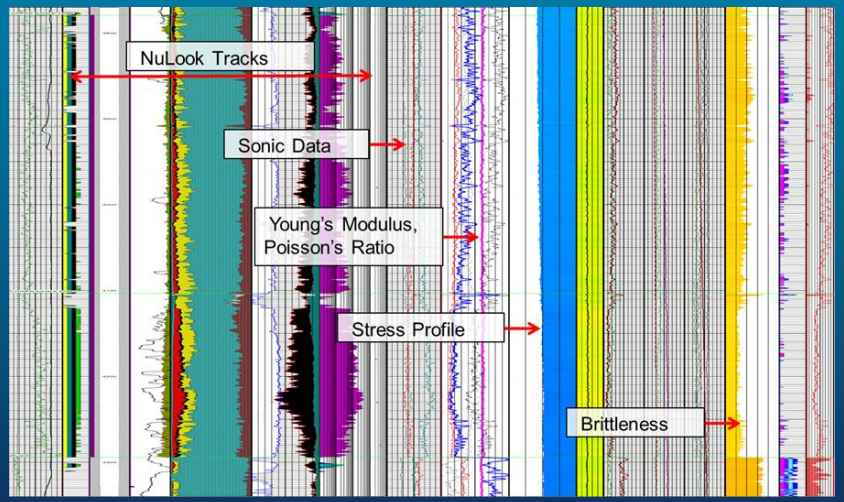
Unconventional Analysis in New Plays

- Use of depositional analogs
- Use of local knowledge and available research
- Core Analysis
- NULOOK petrophysical analysis
- Geo-Mechanical modeling using sonic data and calibrated acoustic modeling
- NUSTIM multi-scenario completion design for vertical section
- NUSTIM optimization of spacing for horizontal completion



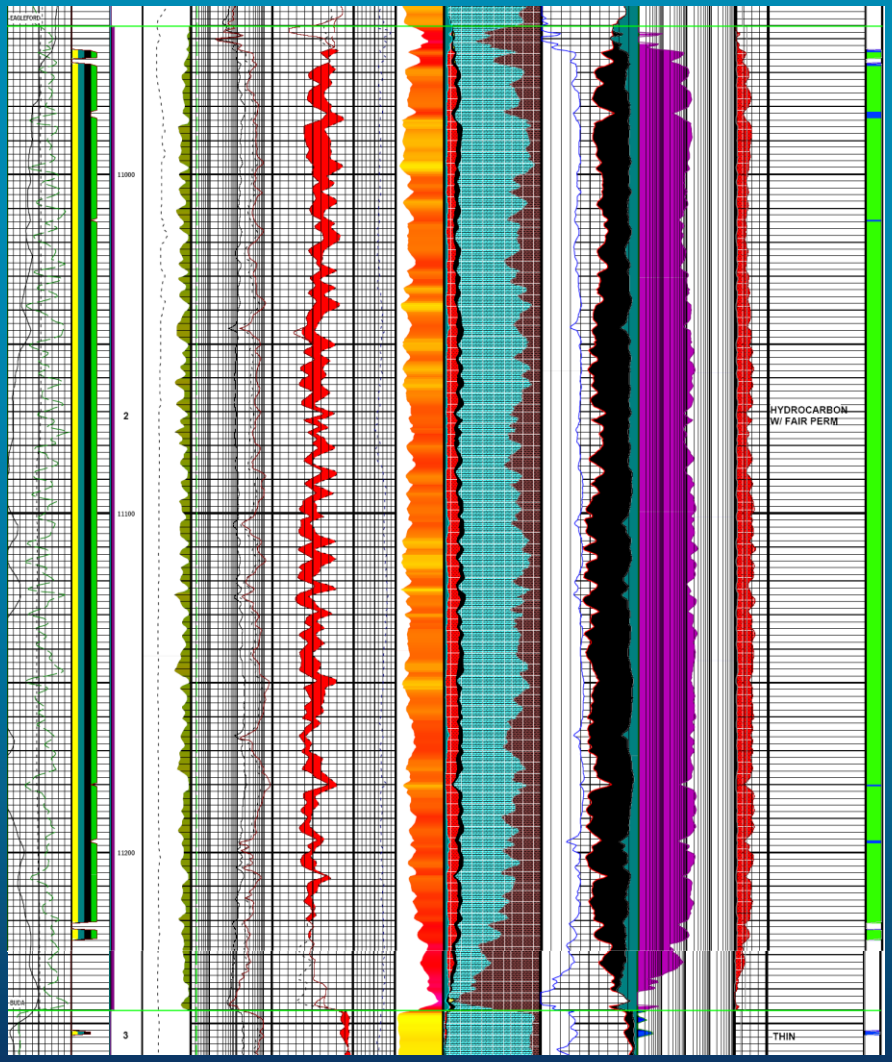
Source: BHPBilliton (Formerly Petrohawk)



© NUTECH Geo-mechanical log Eagle Ford example

Petrophysical Process

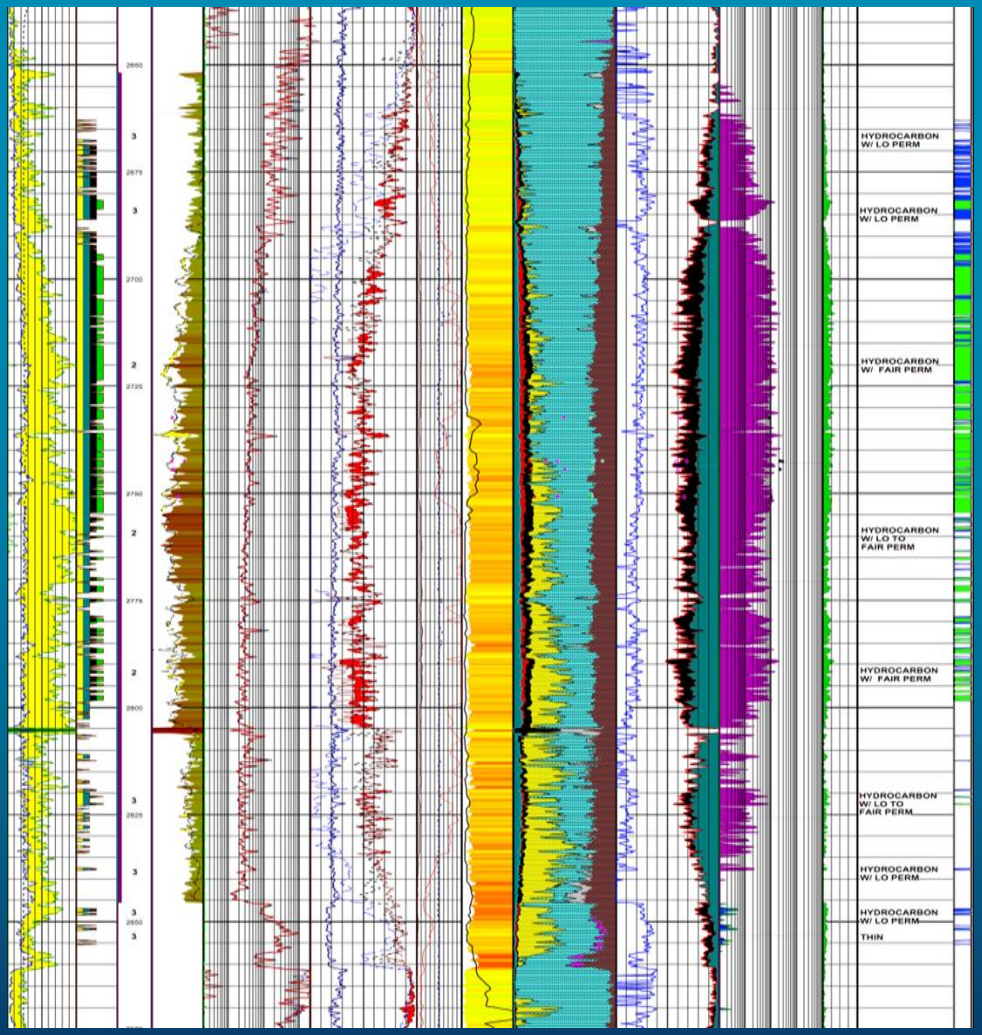
- Determine Clay Volume using multiple clay indicators
- Determine Kerogen fraction using modeling from GR, Resistivity, Density, and Neutron
  - Gamma Ray Method (Uranium Model) Russell 1945 & Fertl 1978
  - Density Method (Modified Schmocker) Schmocker 1983
  - Resistivity Method (Modified Passey) Meyer 1984 & Passey 1990
- Correct for Kerogen effect on log data
- Use Kerogen corrected data to solve for Silica, Lime, Heavy Minerals, and Porosity



Eagle Ford example La Salle Co., TX

Petrophysical Process

- Determine Bound Water using Multi-Modeling Logic
- Determine Permeability using algorithm developed from completed well production and stimulation matching and/or good core data
- Determine Adsorbed and Free Gas volumes from core determined data (Langmuir Isotherms)



La Pimienta Example, Nuevo León, Mexico

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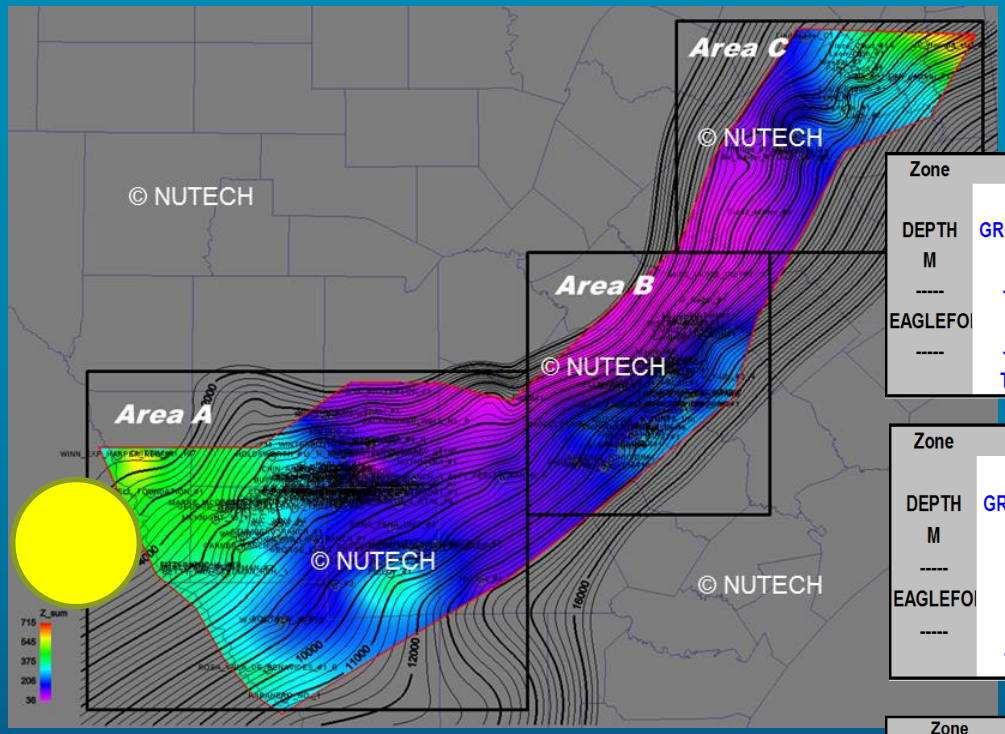
Eagle Ford



© NUTECH Interval Thickness Map

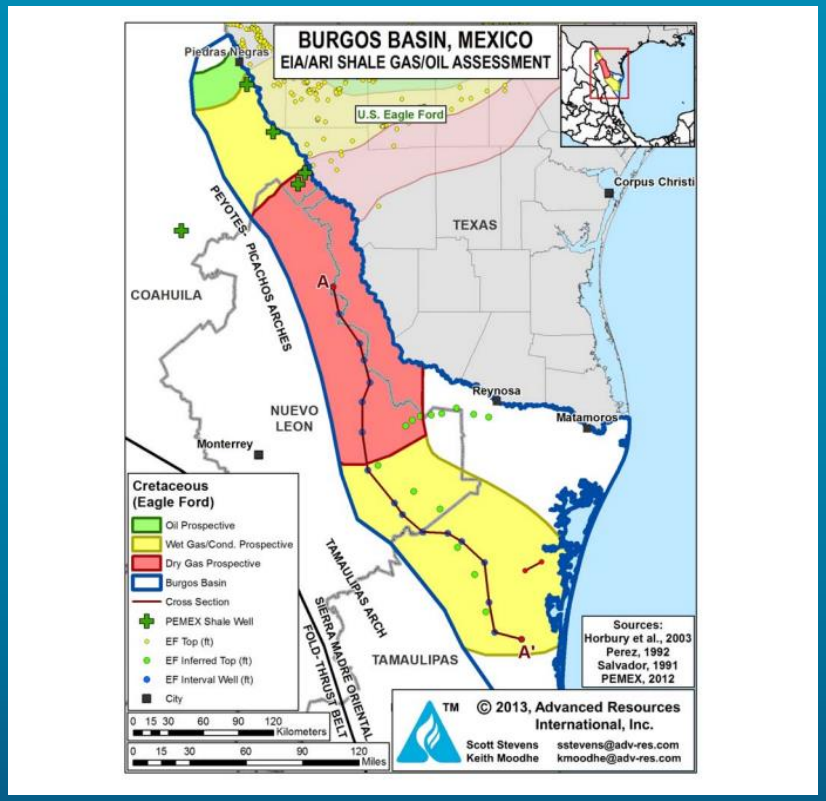
Zone	Summaries			La Salle County "Sweet Spot"						
DEPTH M	GROSSM	PAYM	RANK	CLAY DEC	PHIE DEC	SW DEC	PERMSH uD	HydPorM POR-M	PERMSHM uD-M	TOC %
---	---	---	---	---	---	---	---	---	---	---
EAGLEFO	79	64	2.4	0.245	0.094	0.399	0.598	4.952	46.987	3.362
---	---	---	---	---	---	---	---	---	---	---
	TOT	TOT	AVGX	AVGX	AVGX	AVGX	AVGX	CUM	CUM	AVGX

Zone	Summaries			5- Well Average Statistics						
DEPTH M	GROSSM	PAYM	RANK	CLAY DEC	PHIE DEC	SW DEC	PERMSH uD	HydPorM POR-M	PERMSHM uD-M	TOC %
---	---	---	---	---	---	---	---	---	---	---
EAGLEFO	89	67	2.7	0.289	0.087	0.453	0.460	4.848	39.379	2.956
---	---	---	---	---	---	---	---	---	---	---
	TOT	TOT	AVGX	AVGX	AVGX	AVGX	AVGX	CUM	CUM	AVGX

Zone	Summaries			Well Statistics						
DEPTH M	GROSSM	PAYM	RANK	CLAY DEC	PHIE DEC	SW DEC	PERMSH uD	HydPorM POR-M	PERMSHM uD-M	TOC %
---	---	---	---	---	---	---	---	---	---	---
EAGLEFORD	84.9	70.5	2.6	0.296	0.102	0.447	0.537	5.105	45.609	4.302
---	---	---	---	---	---	---	---	---	---	---
	TOT	TOT	AVGX	AVGX	AVGX	AVGX	AVGX	CUM	CUM	AVGX

© NUTECH Eagle Ford Comparison

La Pimienta



Eagle Ford, La Casita and La Pimienta formations map.
Source: EIA/ARI World Shale Gas and Shale Oil Resource Assessment 2013

- Upper Jurassic deposition
- EIA/ARI: “Correlates with the productive Haynesville shale of the East Texas Basin”
- Expected TOC: ~3%
- Expected Thermal Maturity: >1.4% Ro (Gas)
- BUT Anhélido-1 well had IP of 432 BOPD + 1.9 MMCFPD (Source: Pemex)

PEMEX

Main Discoveries in 2012

Project	Well	Geologic Age	Initial Production Oil & Condensates (bd)	Initial Production Gas (MMcfd)	Type of Hydrocarbons
Burgos	Master-1	Cretaceous		20.7	Dry Gas
	Tepozan-1	Tertiary	34	2.2	Wet Gas
	Paje-1	Tertiary	72	1.1	Wet Gas
	Anhelido-1	Jurassic	432	1.9	Gas and Condensates

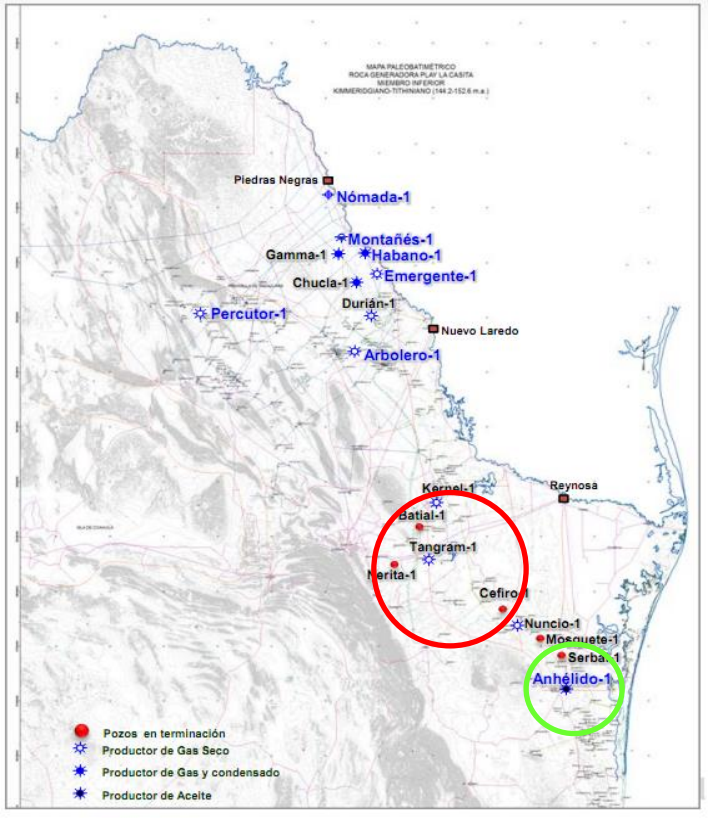
Source: Pemex Preliminary Results 2012

La Pimienta- Haynesville Comparison

Zone	Summaries												
DEPTH M	GROSSM	PAYM	RANK	CLAY DEC	PHIE DEC	SW DEC	PERMSH uD	HydPorM POR-M	PERMSHM uD-M	TOC %	Total GIP BCF/sec	Adsorbed GIP BCF/sec	Free GIP BCF/sec
---	---	---	---	---	---	---	---	---	---	---	---	---	---
LA PIMIENTA	194	94	2.3	0.119	0.084	0.654	0.413	6.184	80.1913	3.633	161.482	70.044	91.438
---	---	---	---	---	---	---	---	---	---	---	---	---	---
	TOT	TOT	AVGX	AVGX	AVGX	AVGX	AVGX	CUM	CUM	AVGX	CUM	CUM	CUM

© NUTECH La Pimienta NULOOK

Shale Play	Haynesville/ Bossier	LA Pimienta NUTECH	La Pimienta ARI
Region	East TX/ LA		
Geology			
Age	Late Jurassic		
Basin	East TX/North LA Salt		
Area (Sq Miles)	9,000		9,000
Depth (Ft)	10,500-13,500	8,200-9,100	3,300-8,500
Thickness (Ft)	200-300	300-375	200-500
Quartz (Wt %)	30-35%	20-40%	
Carbonate (Wt %)	13-44%	25-60%	
Clay (Wt %)	35-45%	10-20%	Low
Reservoir Rock			
Temperature (°F)	300-370	260-280	
Reservoir Pressure (Psi)	9,000-11,000		Normal
Pressure Gradient (Psi/Ft)	0.8-0.9		
Permeability (µD)	0.1-1	0.4	
Porosity (%)	8-10%	8.40%	
YM (x10^6 Psi)	2-5	2-8	
Poisson's Ratio	0.2-0.35	0.25-0.35	
Brinell Hardness Number	18		
Fracture Gradient (Psi/Ft)	1		
Play Maturity			
TOC (%)	0.5-4%	0.1 - 4.5	3%
Kerogen Type	Type II	Type II	
Thermal Maturity (% Ro)	1.8-2.5%	0.85 - 2.2%	0.85-1.4%
Tmax (°F)	905-940	822-850	
HI (mg HC/g TOC)	100-205	78-249	
S1/TOC (mg HC/g TOC)	39		



Sources: © NUTECH Unconventional Catalog/ EIA/ARI World Shale Gas and Shale Oil Resource Assessment 2013

Source: Presente y Futuro del Proyecto Burgos – Texas Energy Summit – November 2013

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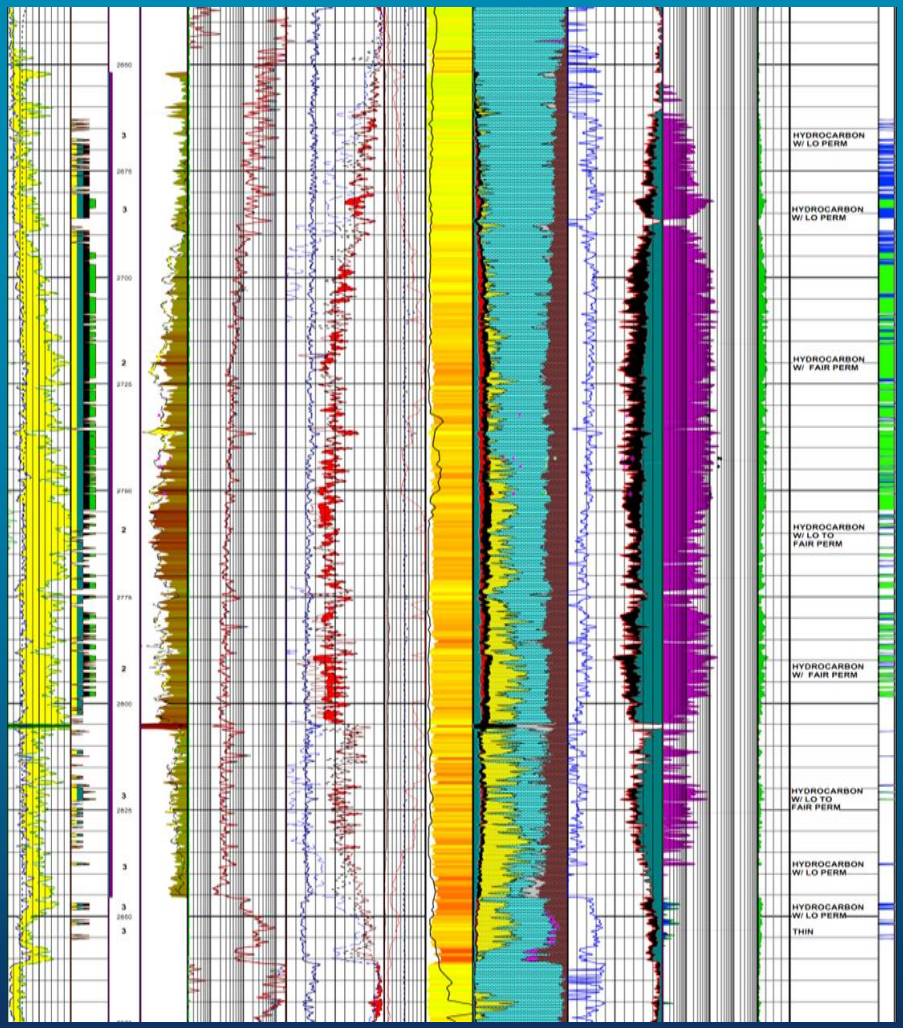
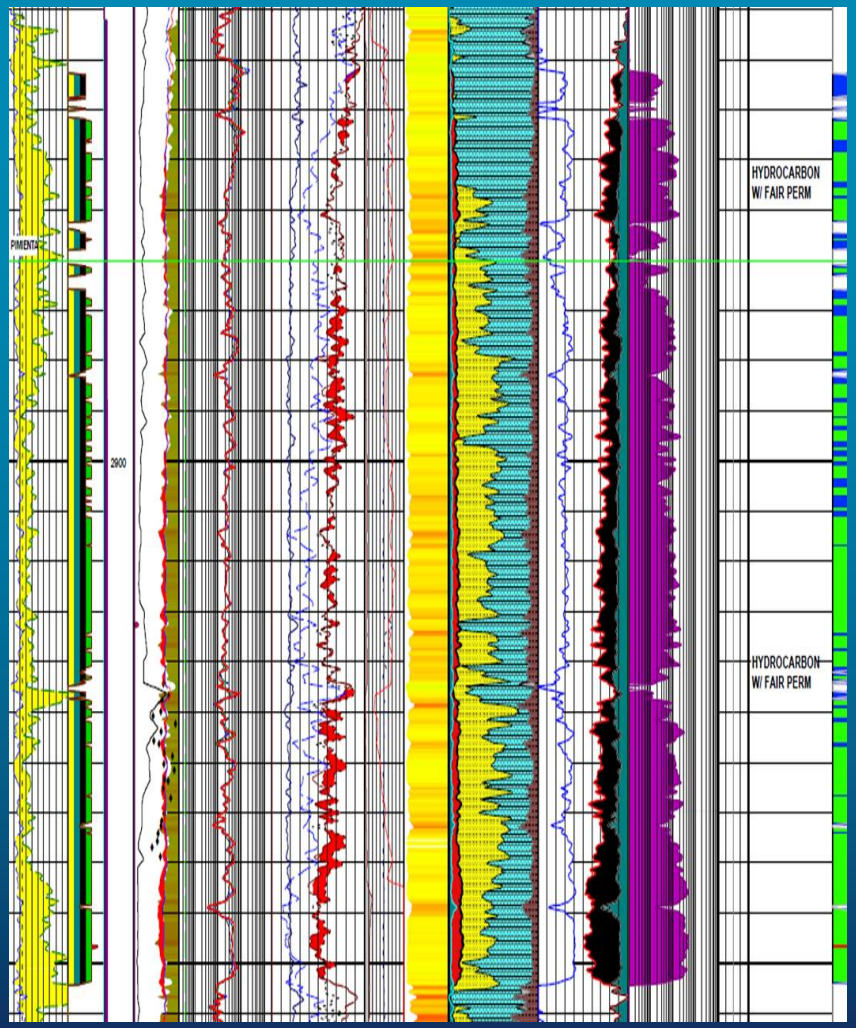
Tangram-1 and Céfiro-1 Evaluations

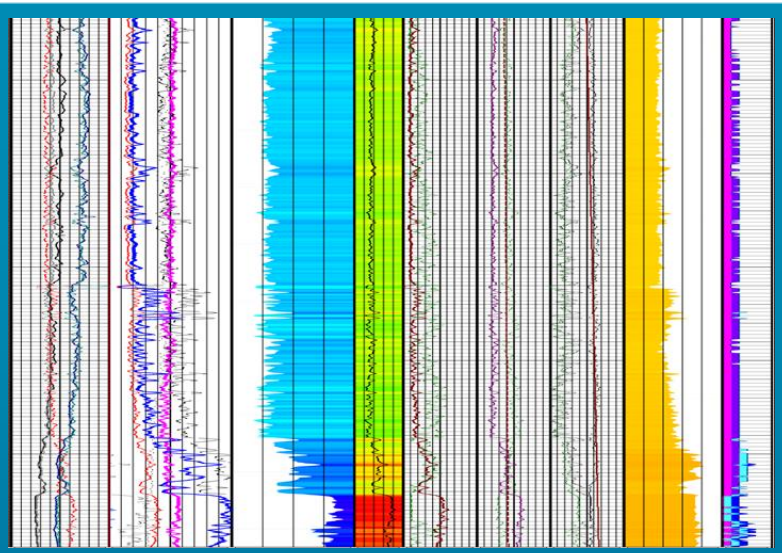
Tangram-1



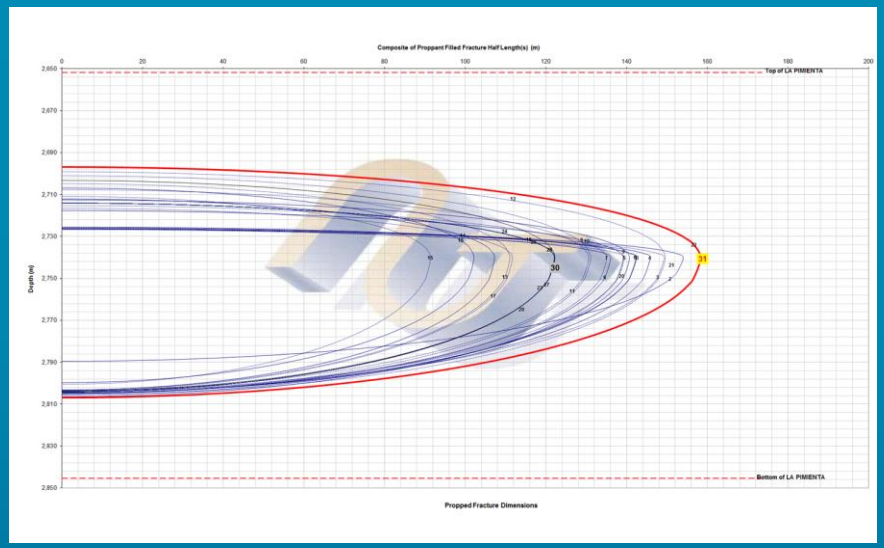
Céfiro-1



Tangram-1 Completion

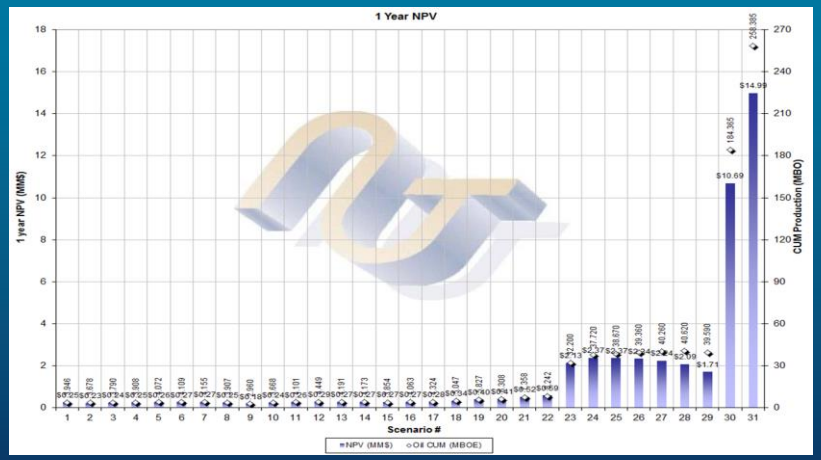


© NUTECH Tangram-1 Geo-mechanical Log



© NUTECH Tangram-1 Completion Scenarios

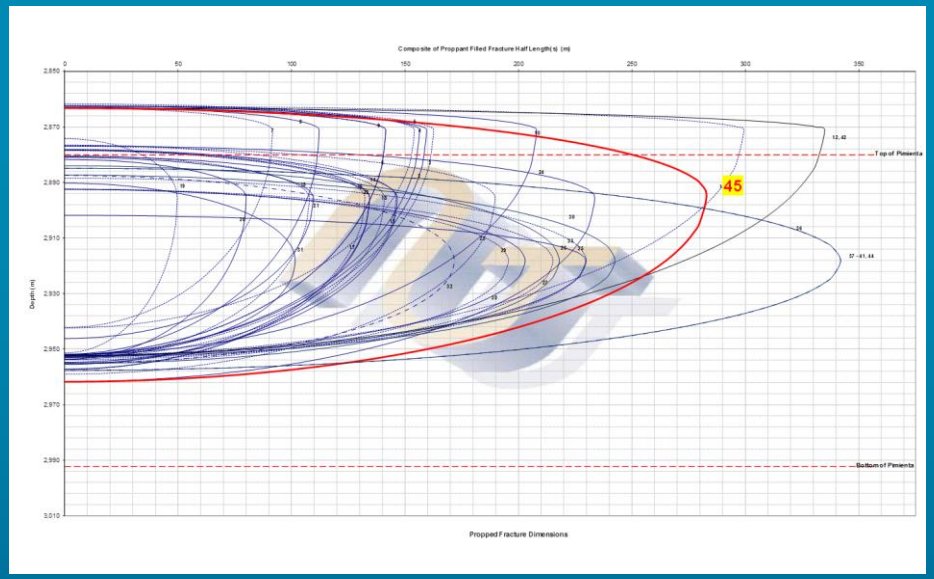
- Recommended completion based on 1-year NPV as requested by Client
- Completion optimized in the vertical section for different variables of proppant type and concentration, injection rate, treatment size
- Horizontal spacing optimized based to maximize customer-specific financial terms



Céfiro-1 vs. Tangram-1 Completions

- For the Céfiro-1 well, the client requested the evaluation of treatments in three different landing depths

- The selected scenario was not the most optimal for production because horizontal trajectory had been drilled



- The mainstream approach to completion design in unconventional reservoirs is to use “Best Practices” for a specific field. However, the stratigraphic variation and geo-mechanical heterogeneity typical of shale reservoirs makes this approach inefficient. Even though Tangram-1 and Cefiro-1 are in the same field, their completion design was significantly different

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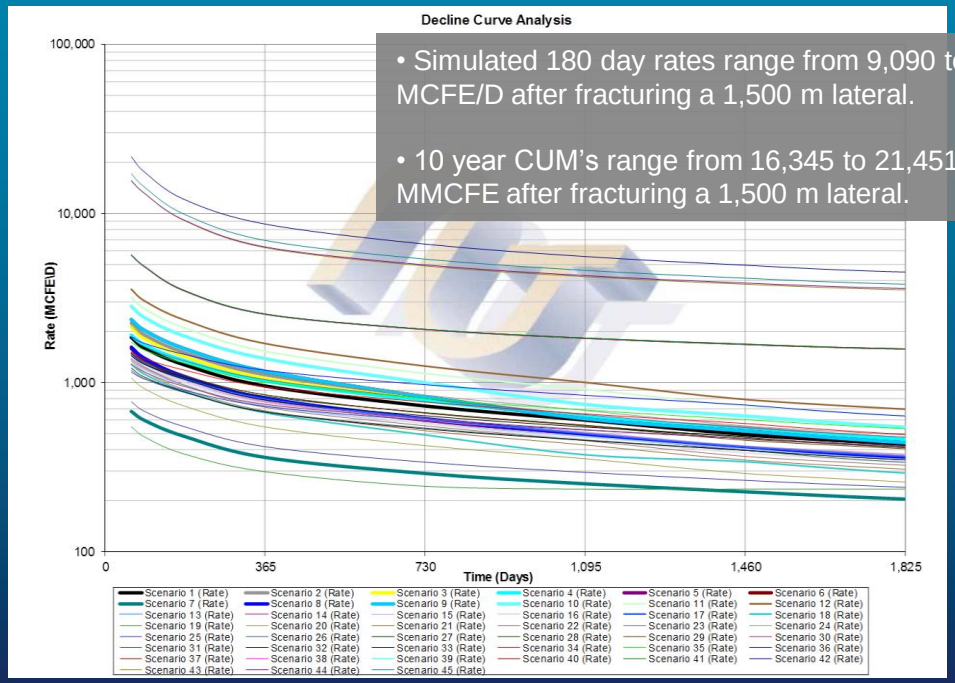
Production

Both Tangram and Céfiro-1: IP: 10.9 MMCFPD (in-line with NUTECH's prediction)

Céfiro-1 production reached over 12 MMCFPD and Pemex estimates it could get to 20 MMCFPD but do not have the surface facilities

Tangram-1 and Céfiro-1 are the best two shale gas wells in Mexico



- Simulated 180 day rates range from 9,090 to 12,101 MCFE/D after fracturing a 1,500 m lateral.
- 10 year CUM's range from 16,345 to 21,451 MMCFE after fracturing a 1,500 m lateral.

© NUTECH Production decline projections

Source: Pemex

Exploración

Año	Cons.	Localización	Prof. md	Prod. Inicial MMpcd	Prod. Inicial Bpd
2010	1	Emergente-1	4,071	2.8	
2011	2	Nómada-1	2,850	Trazas	
	3	Montañés-1	3,200	0.1	
2012	4	Percutor-1	3,436	2.2	
	5	Habano-1	3,770	2.8	27
	6	Arbolero-1	4,007	3.1	
	7	Anhélido-1	3,550	1.9	333
2013	8	Chucla-1	4,100	1.9	24
	9	Durián-1	4,200	1.9	
	10	Nuncio-1	4,900	2.9	
	11	Gamma-1	3,793	0.3	12
	12	Kernel-1	4,404	2.8	
	13	Tangram-1	4,426	10.9	
	14	Serbal-1	4,800		
	15	Batial-1	4,196		
	16	Céfiro-1	4,700		
	17	Mosquete-1	4,181		
	18	Nerita-1	3,810		

Source: Presente y Futuro del Proyecto Burgos – Texas Energy Summit – November 2013

Lessons Learned

- La Pimienta shows geologic similarities to the Haynesville formation in East Texas but with better expected production rates and a likely oil window to the south
- Carbonate content increases S-N as the formation dips deeper
- Landing points should be selected based on stratigraphic changes in the formation
- Geo-mechanical variation is key to proppant selection
- Eagle Ford completions can be improved with proper proppant selection and treatment size optimization
- Less economical wells should be used for field characterization
- “Best Practices” approach not ideal for La Pimienta and Eagle Ford formations

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