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

Jorge Viamontes, PhD
VP Reservoir Intelligence, NUTECH

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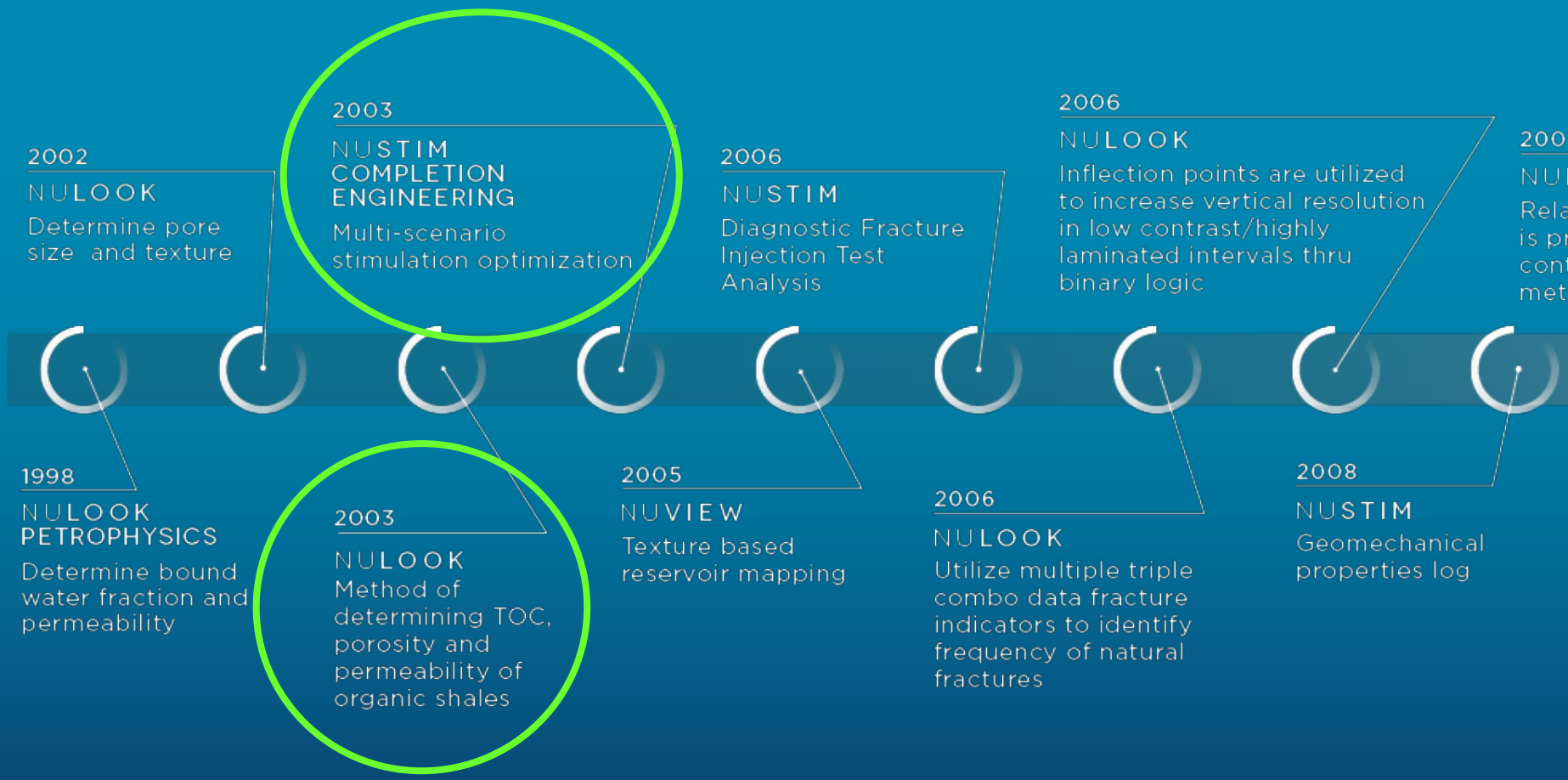
Presentation Outline

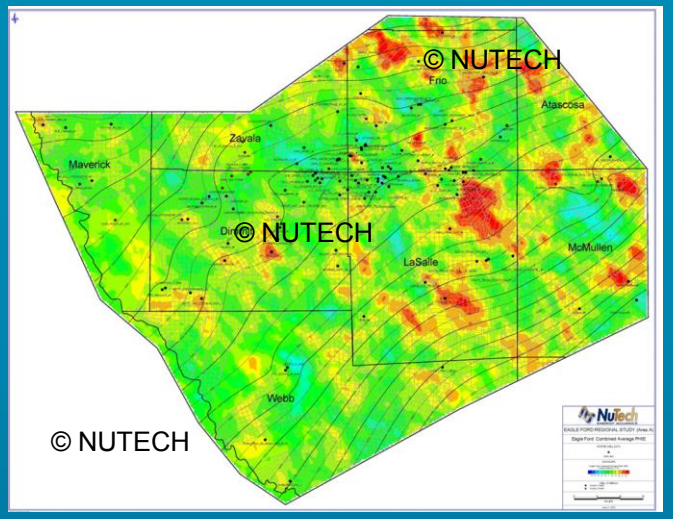
- NUTECH experience in the Eagle Ford and Burgos Basins
- How NUTECH's unconventional analysis process is used in new shale plays
- Highlight similarities and differences between the Eagle Ford, Haynesville and La Pimienta formations
- Tangram and Céfiro examples – Petrophysical analysis, geomechanical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

NUTECH Timeline



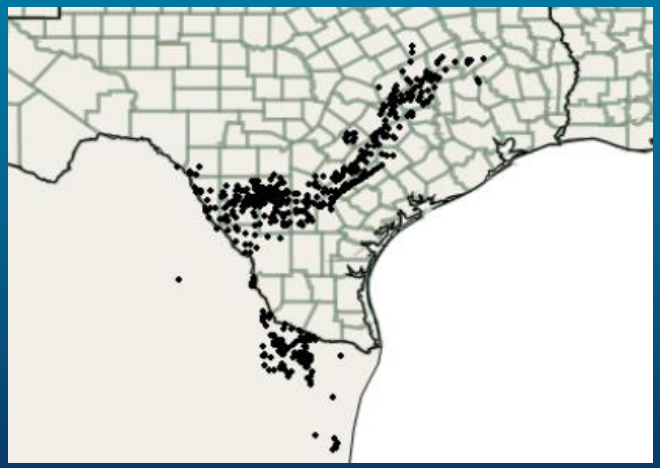
NUTECH Experience in the Eagle Ford and Burgos Basins

- 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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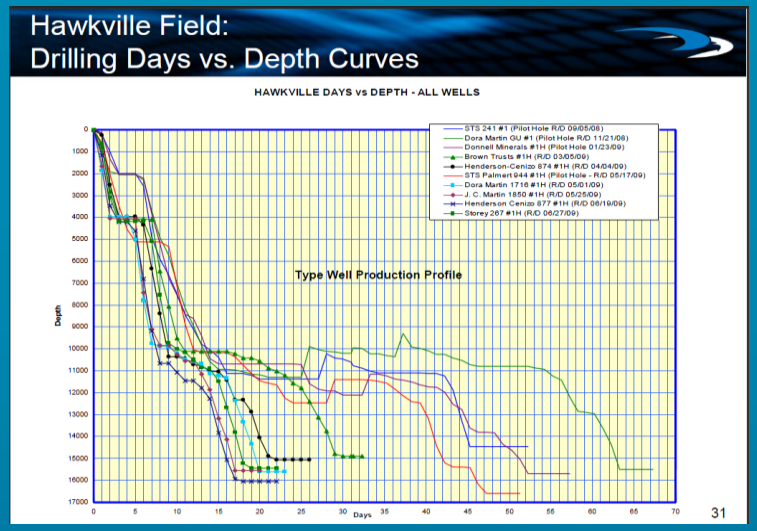
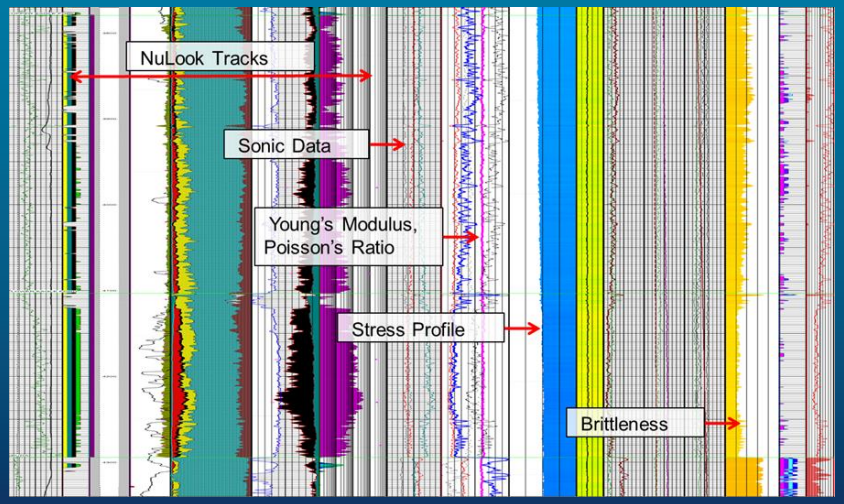
Unconventional Analysis in New Plays

- 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



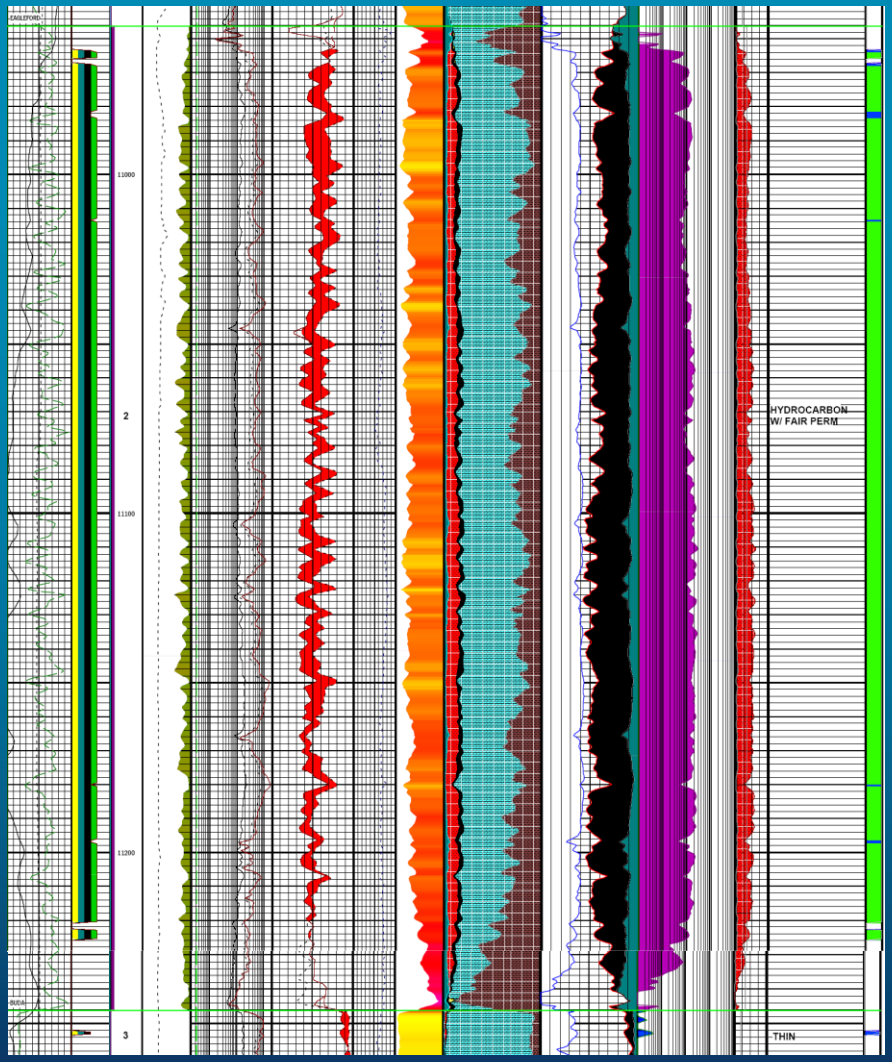
Source: BHPBilliton (Formerly Petrohawk)



© NUTECH Geo-mechanical log Eagle Ford example

Petrophysical Process

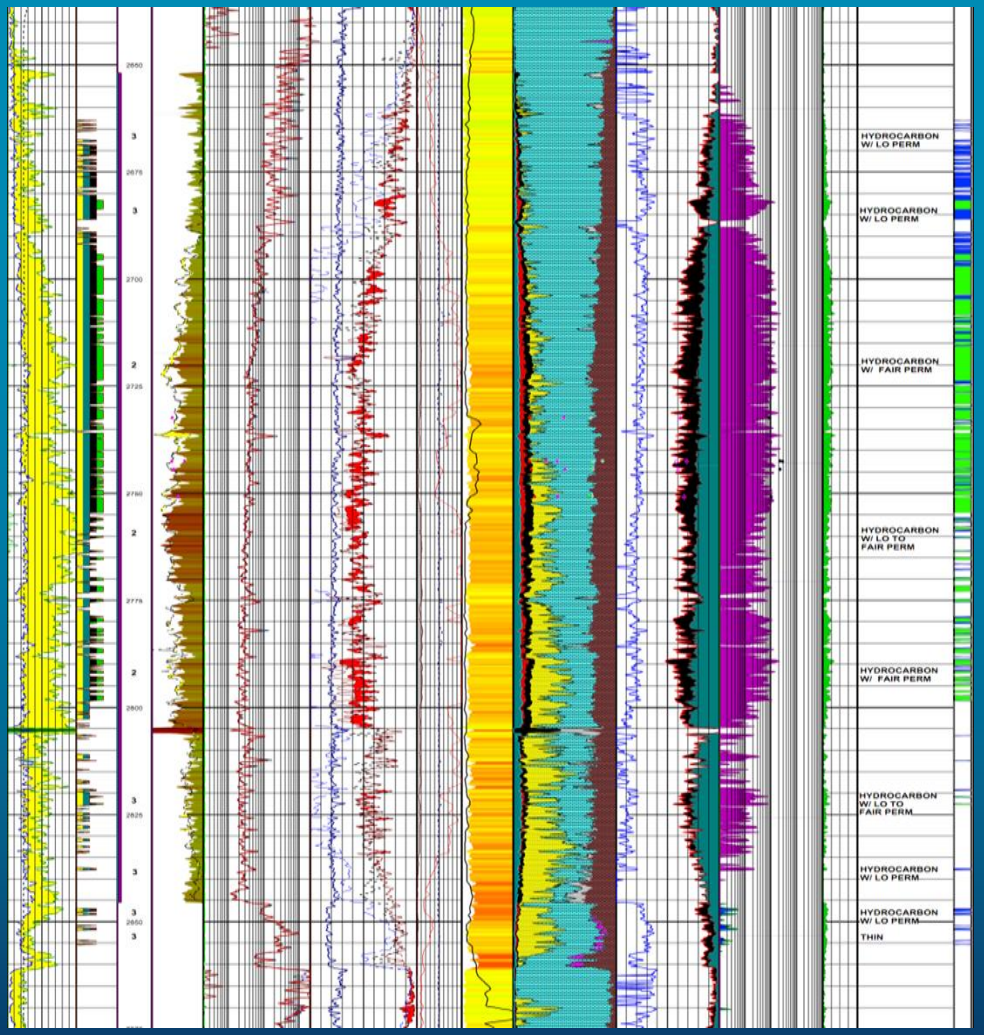
- Determine Clay Volume using multiple clay indicators
- Determine Kerogen fraction using modeling from GR, Resistivity, Density, and Neutron
  - Gamma Ray Method (Uranium Model) Russell 1945 & Fertl 1978
  - Density Method (Modified Schmocker) Schmocker 1983
  - Resistivity Method (Modified Passey) 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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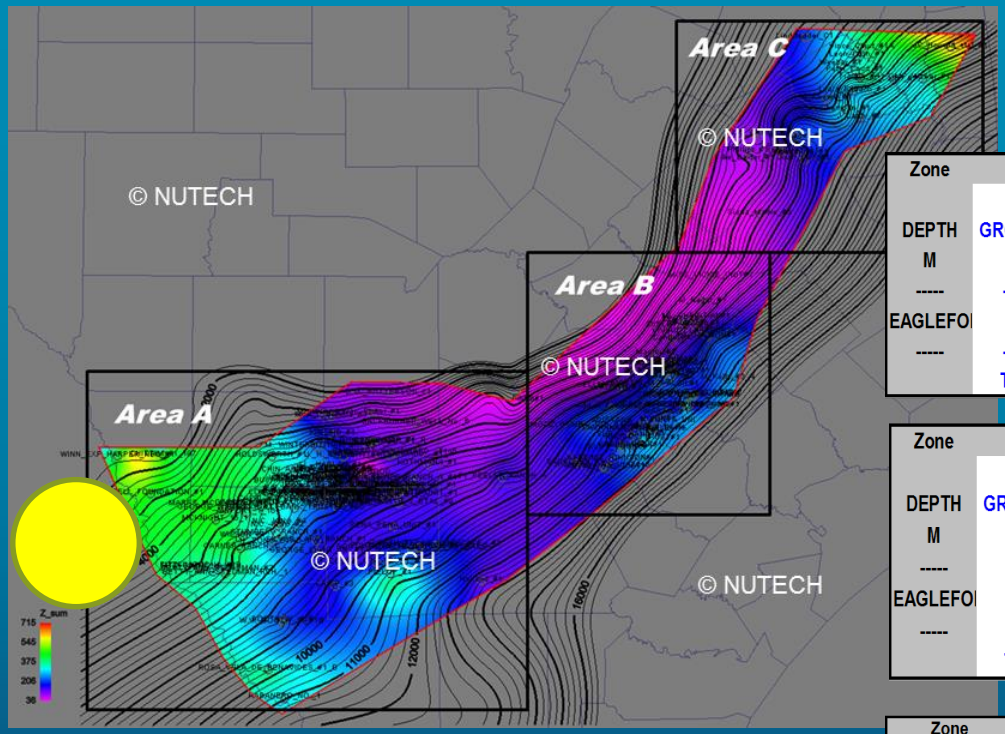
Eagle Ford



© 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*

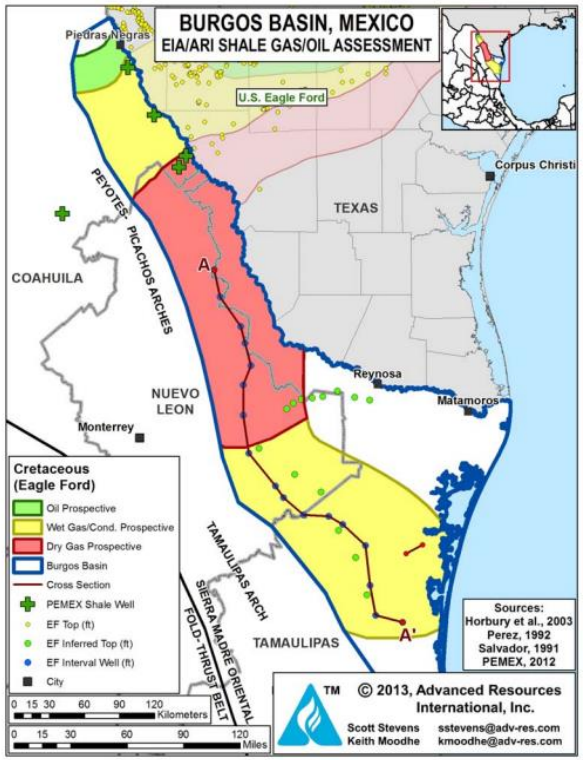
DEPTH M	GROSSM	PAYM	RANK	CLAY DEC	PHIE DEC	SW DEC	PERMSH uD	HydPorM POR-M	PERMSHM uD-M	TOC %
EAGLEFO	89	67	2.7	0.289	0.087	0.453	0.460	4.848	39.379	2.956
	TOT	TOT	AVGX	AVGX	AVGX	AVGX	AVGX	CUM	CUM	AVGX

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

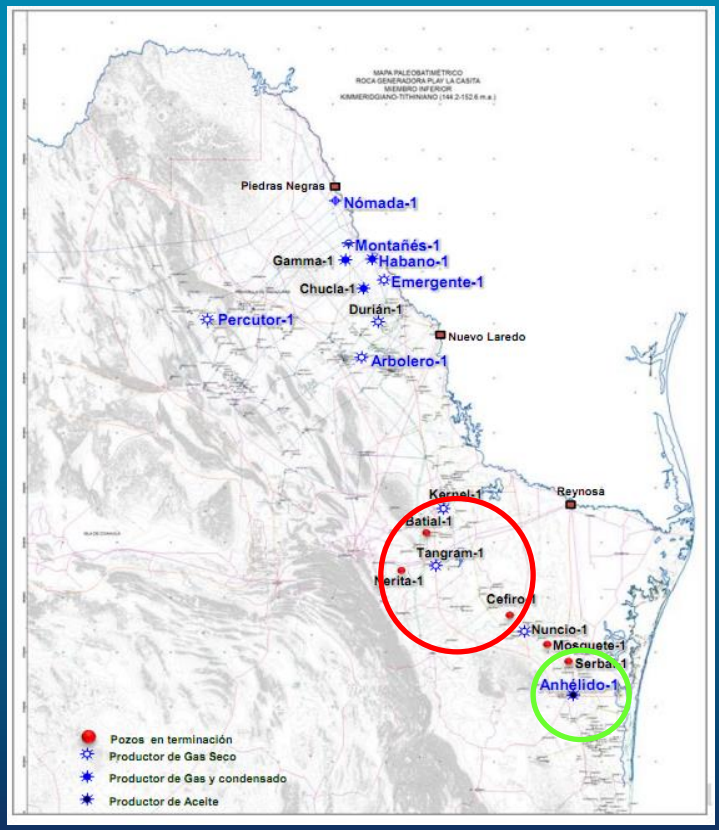
Source: Pemex Preliminary Results 2012

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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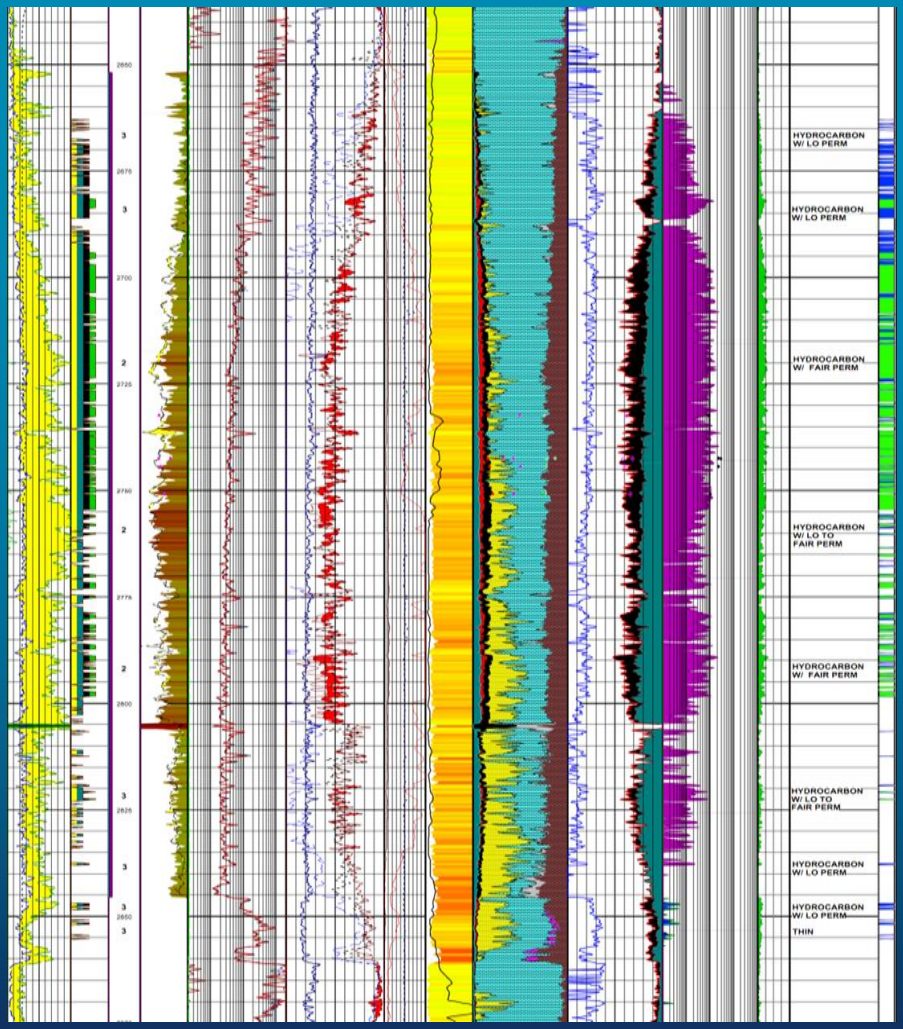
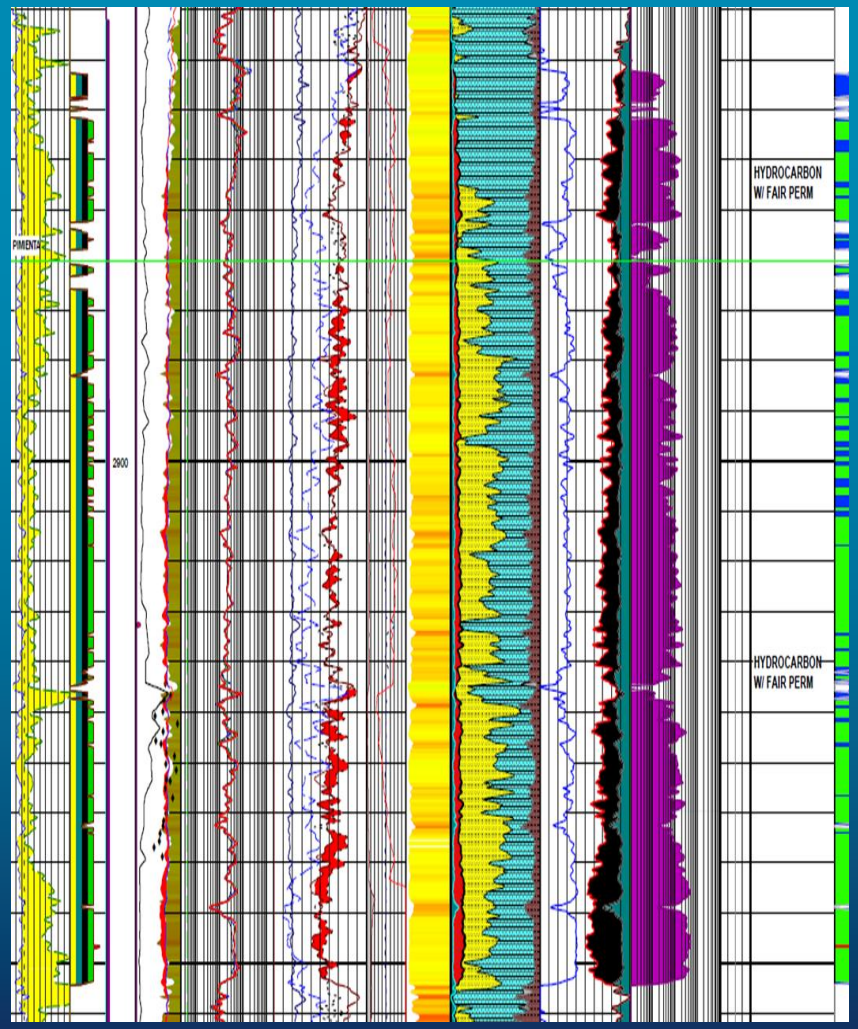
Tangram-1 and Céfiro-1 Evaluations

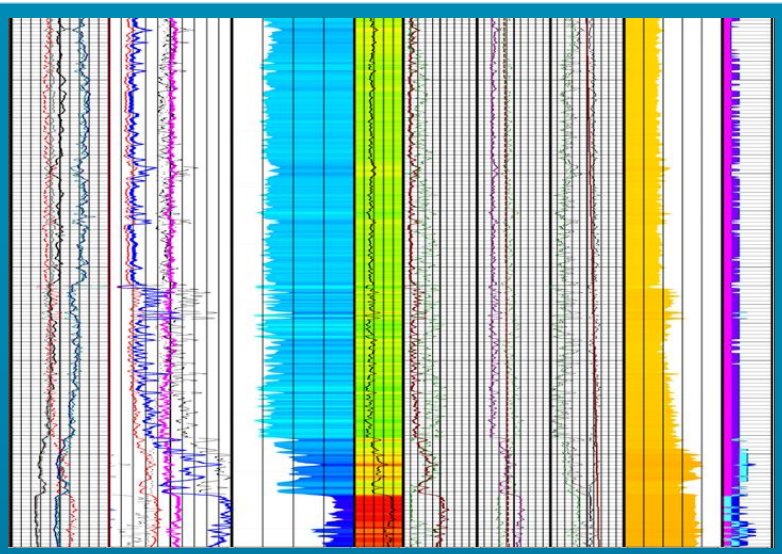
Tangram-1



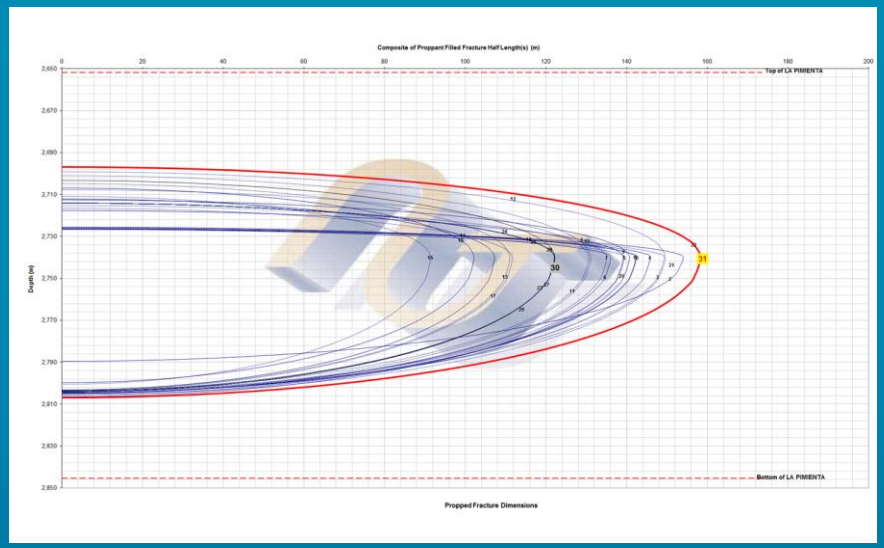
Céfiro-1



Tangram-1 Completion

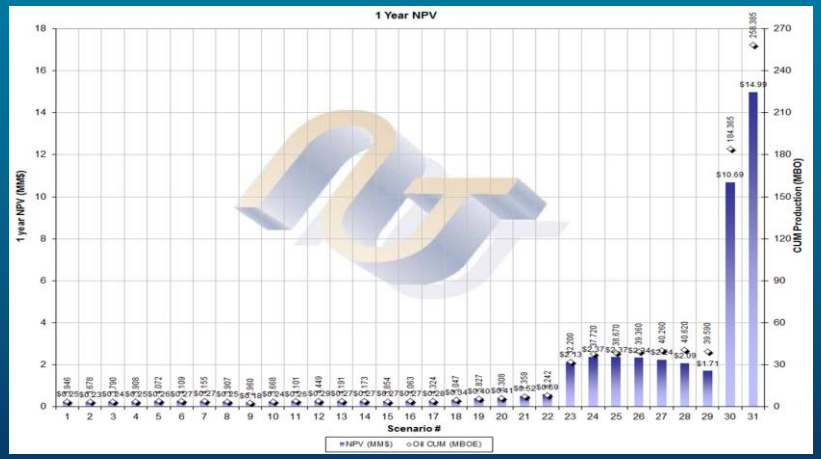


© NUTECH Tangram-1 Geo-mechanical Log



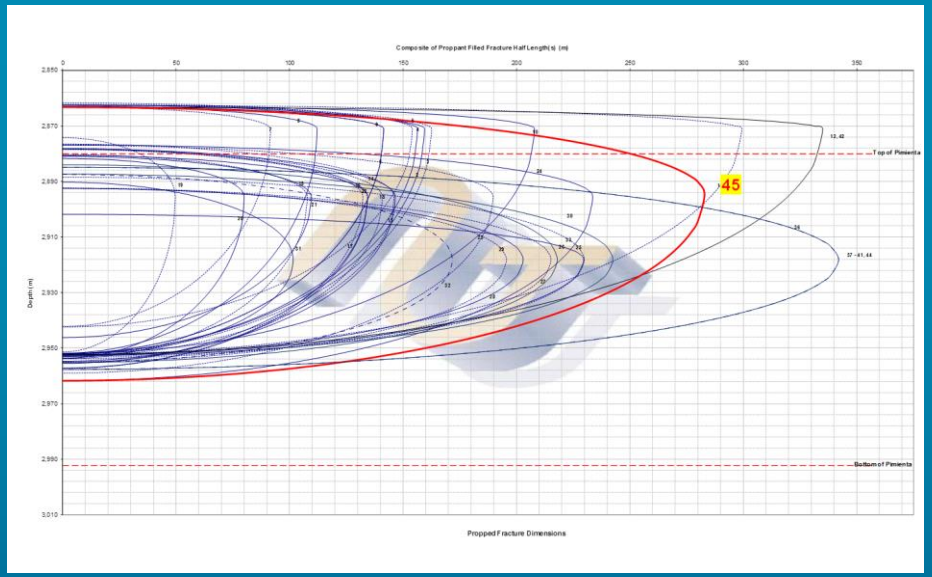
© NUTECH Tangram-1 Completion Scenarios

- 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

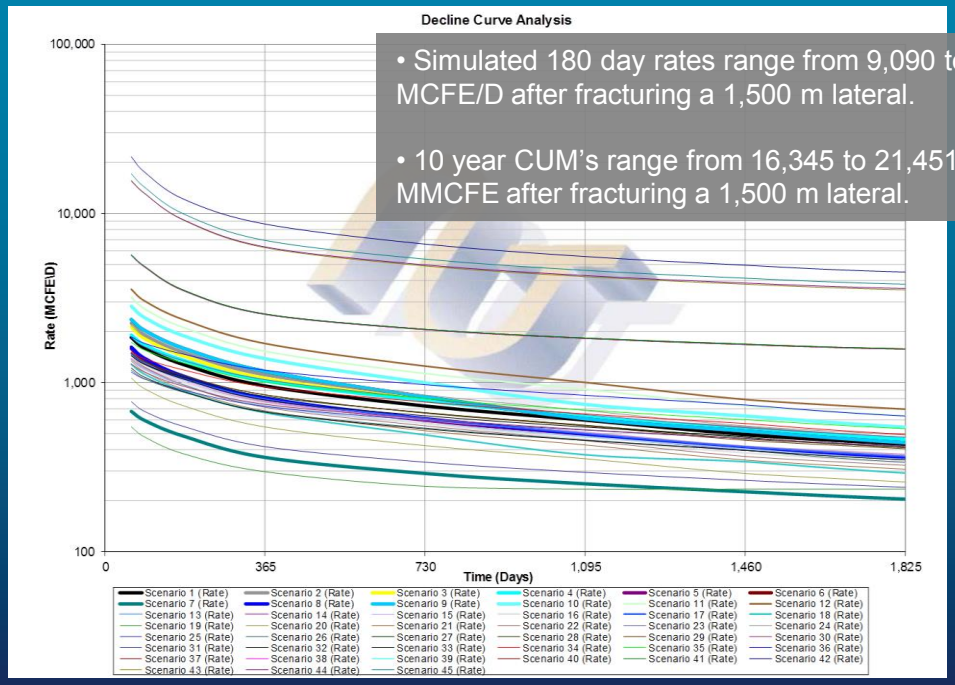
Source: Pemex

PEMEX EXPLORACION Y PRODUCCION

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



- 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

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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