



# 2015 CO<sub>2</sub> Conference Week

Wednesday, December 9, 2015

## ***Seminar on the Origins, Processes and Exploitation of Residual Oil Zones***

Midland Center

Midland, Texas

# Table of Contents for the ROZ Seminar

## Section

- 1 Introduction: The Evolving Understanding of ROZs.....Melzer
- 2 The Science of ROZs .....Trentham/Vance
- 3 ROZ Properties and Characteristics .....Melzer
- Break*
- 4 The Permian Basin ROZ Resource (San Andres  
Formation) .....V Kuuskraa/ARI
- 5 CO<sub>2</sub> EOR and Depressuring the Upper ROZ (DUROZ)  
Case Histories .....Trentham/Melzer
- 6 Big Horn Basin (Wy) ROZs .....EORI/Melzer
- 7 Williston Basin (ND, SD) ROZs .....Melzer
- 8 ROZ Wrap-up and Buffet Lunch .....Melzer

*Optional Field Trip to Seminole San Andres Unit (Separate Ticket Required)*

*5:30 -7:30 pm - Reception at the Midland Center*



## Section 3

# ROZ Rock and Fluid Properties and Characteristics

*What the Field Data Tells Us*

Steve Melzer

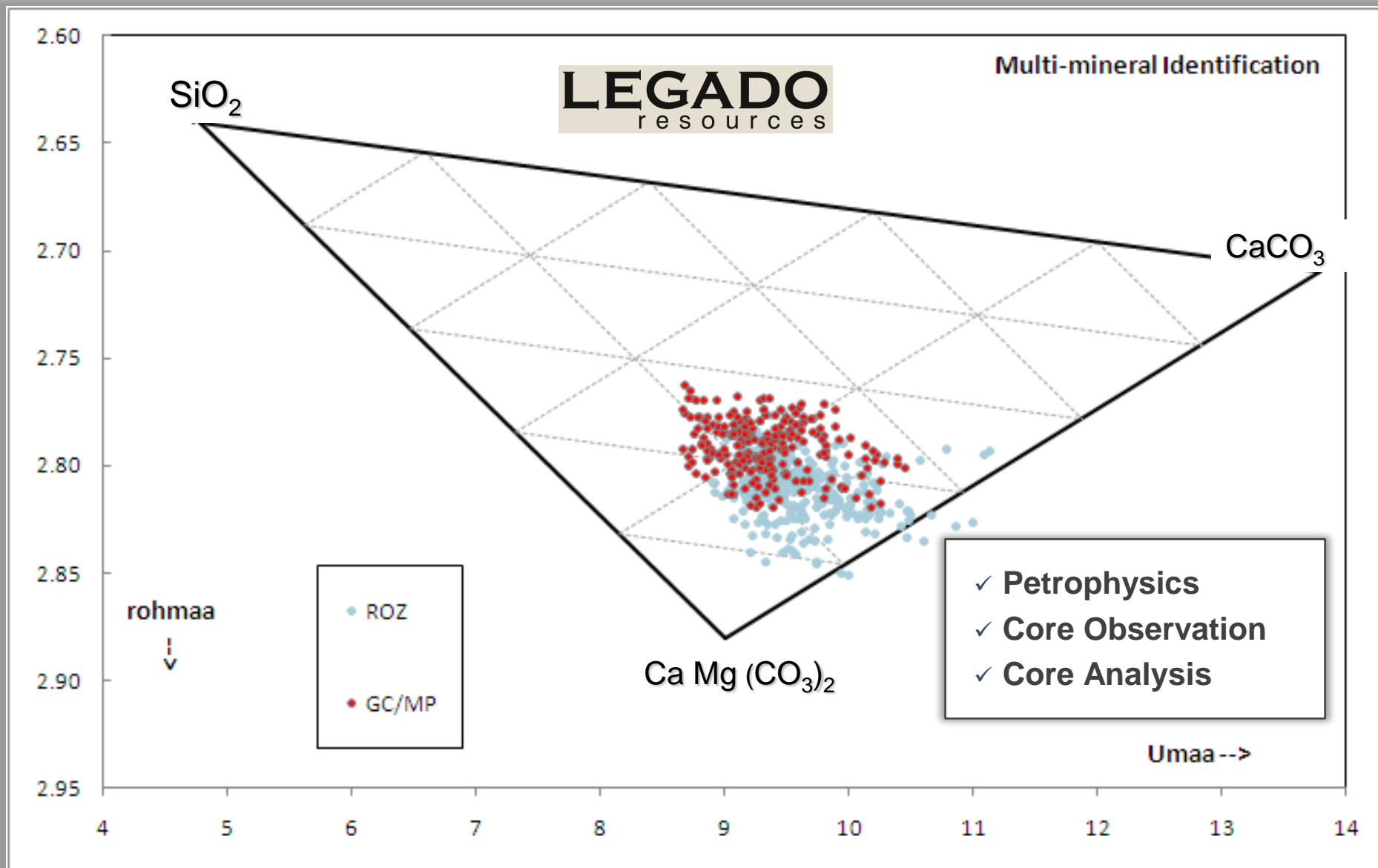


# ROZ Rocks/Oils/Waters

## *Outline*

- Late Stage Diagenetic Overprinting
- ROZ Oils
- ROZ Waters

# MPZ vs. ROZ Petrophysics



Gamma Ray  
Log

Neutron

**Bow-Shaped  
Log  
Character**

**Northern  
Central Basin  
Platform  
Area**

First Cavings Sample Shows = 5330'

ROZ

Base of Cuttings 'Strong  
Flour' = 5620'

PDI

5000'

5500'

6000'

6500'

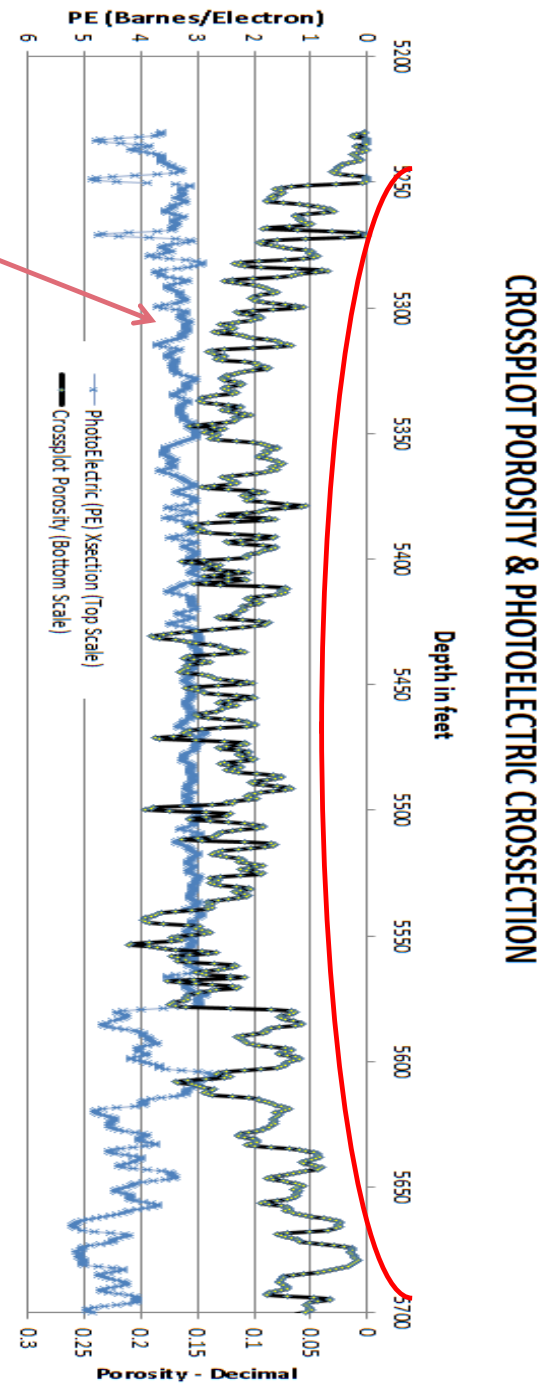
DST 486' Sulfur  
H<sub>2</sub>O

T/Glorieta

**PhotoElectric Cross Sectional Value of 3:  
= Dolomite**  
(Anhydrite and Calcite = 5+)

## Porosity and PhotoElectric Cross Section Log

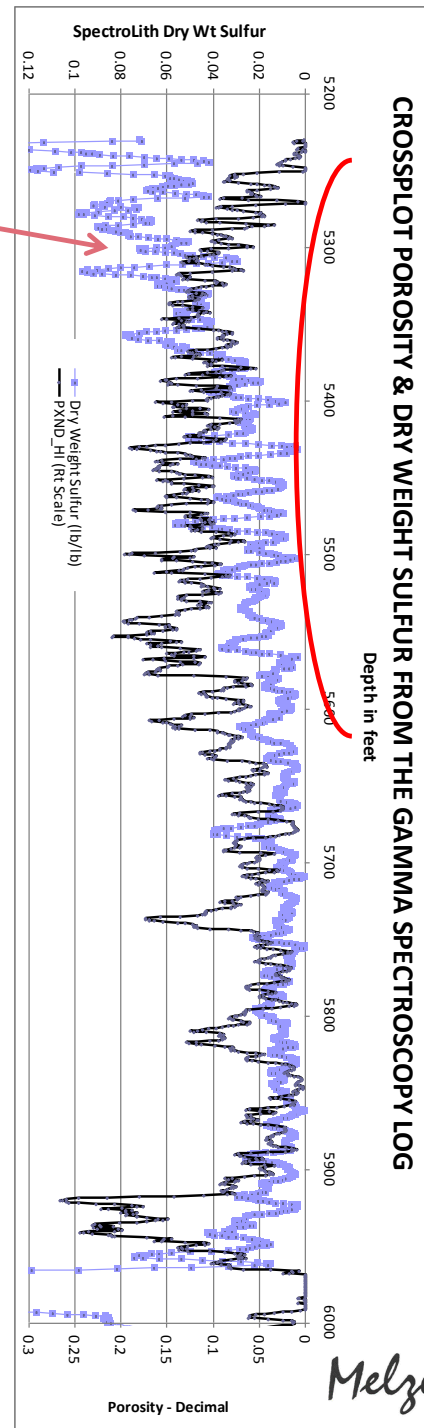
Northern PB San Andres  
Formation Example



Sulfur Track on SpectroLith<sup>®</sup> Computation:  
Increasing Sulfur in the Inverted Transition Zone

## Porosity and Sulfur Composition (Spectroscopy) Log

NE Shelf San Andres  
Formation (PB) Example





# What Do We Know About ROZ Oils?

# SSAU MPZ and ROZ Oils

**Table 5. MPZ/ROZ Fluid PVT and Flow Tests\***

Test Type	Laboratory Test	1978-79 Study	1987 Study	2008 Study	2009 Study
Routine PVT	Composition	X	X	X	
	Psat	X	X	X	
	Constant Composition		X	X	
	Expansion (CCE)	X			
	Differential Liberation (DL)	X	X		
	Separator Tests	X	X	X	
	Viscosity	X	X		
Special PVT	Swelling Test	X			
	CCE Oil + CO <sub>2</sub>	X			
	Viscosity Oil + CO <sub>2</sub>	X			
Flow Tests	Slim Tube Flow Test	X	X	X	X
	MMP Estimate			X	
	Core Flooding (Water Flooding Followed by CO <sub>2</sub> Flooding)				

\* Ref: SPE 133089, Honarpour, M.M. et al (2010), Rock-Fluid Characterization for Miscible CO<sub>2</sub> Injection: Residual Oil Zone, Seminole Field, Permian Basin

# MPZ and ROZ Oil Comparisons

Table 4. ROZ Fluid Composition\*

Component	Composition (mole%)		
	1978-79 MPZ	1987 ROZ	2008-09 ROZ
N2	0.51	0.02	0.04
CO2	2.47	0.02	0.02
H2S	1.96	0	0.00
C1	24.65	20.12	20.10
C2	9.10	9.04	9.07
C3	7.57	6.86	6.95
iC4	1.41	0	0.04
nC4	4.03	3.84	3.90
iC5	1.76	0.03	0.04
nC5	2.03	2.3	2.49
C6	3.54	2.82	2.69
C7+	40.97	54.95	54.66
Total	100.00	100	100.00
MWC7+	224	252	261
Live Oil MW	142	158	158

ROZ  
Oils

\* Ref: SPE 133089, Honarpour, M.M. et al (2010), Rock-Fluid Characterization for Miscible CO<sub>2</sub> Injection: Residual Oil Zone, Seminole Field, Permian Basin

# Remember this Slide?



## Abiotic Chemical Reactions



Let's Think about the Consumed  
Hydrocarbons

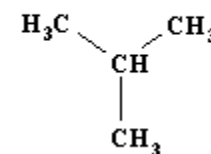
Picked up as Flush  
Water Moves  
through Mg Salts?

# MPZ and ROZ Oil Comps

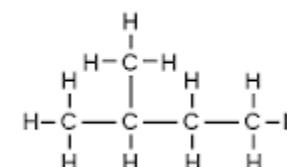
Table 4. ROZ Fluid Composition\*

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C3	7.57	6.86	6.95
iC4	1.41	0	0.04
nC4	4.03	3.84	3.90
iC5	1.76	0.03	0.04
nC5	2.03	2.3	2.49
C6	3.54	2.82	2.69
C7+	40.97	54.95	54.66
Total	100.00	100	100.00
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isobutane



isopentane



\* Ref: SPE 133089, Honarpour, M.M. et al (2010), Rock-Fluid Characterization for Miscible CO<sub>2</sub> Injection: Residual Oil Zone, Seminole Field, Permian Basin

# Other Permian Basin Oil Data

# Hypotheses

- Microbes (Anaerobes) modify oil composition
- Microbes (Anaerobes) create  $\text{H}_2\text{S}$  during the process of oil composition modification (source the S from anhydrite)
- A variety of Sulfurous Chemicals are also a by-product of the Anaerobic Process

*So what evidence of these processes do we have?*

# The Anecdotal Evidence

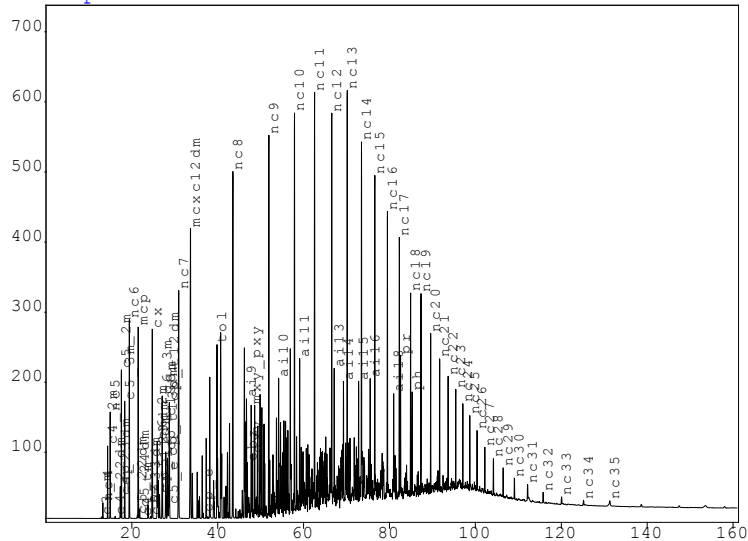
- Sour Oil and “Sulfur Water”
- And How about oil composition changes?



# Permian Basin, San Andres Oil from Goldsmith Field

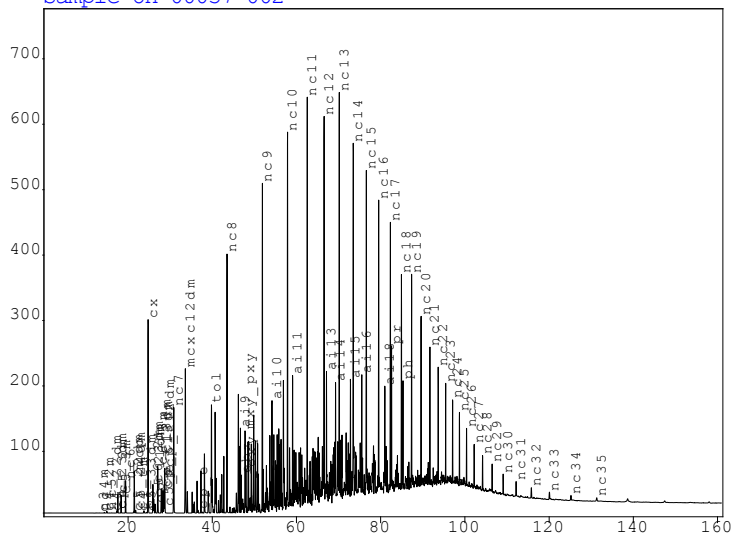
## MPZ Reservoir Oil

Sample UH-00037-001



File: 11G10014.D\FID28.CH  
Date & Time: 3/17/11 4:30:06 PM

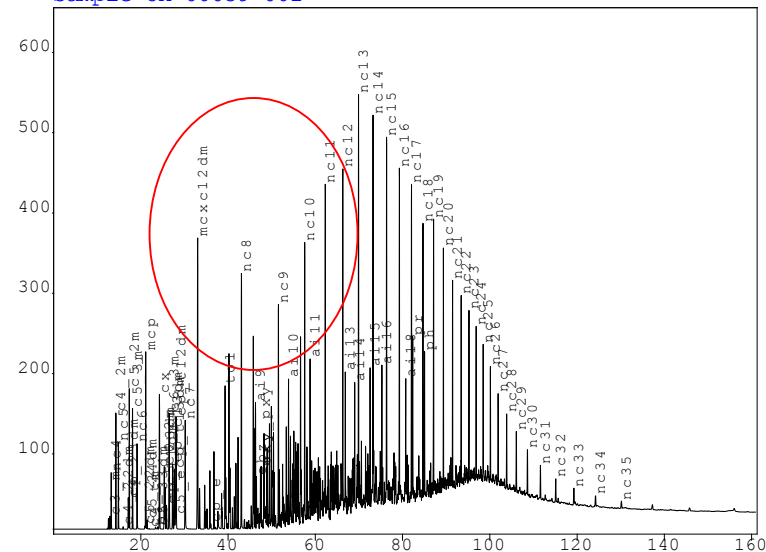
Sample UH-00037-002



File: 11G10015.D\FID28.CH  
Date & Time: 3/17/11 7:47:44 PM

## From ROZ Interval

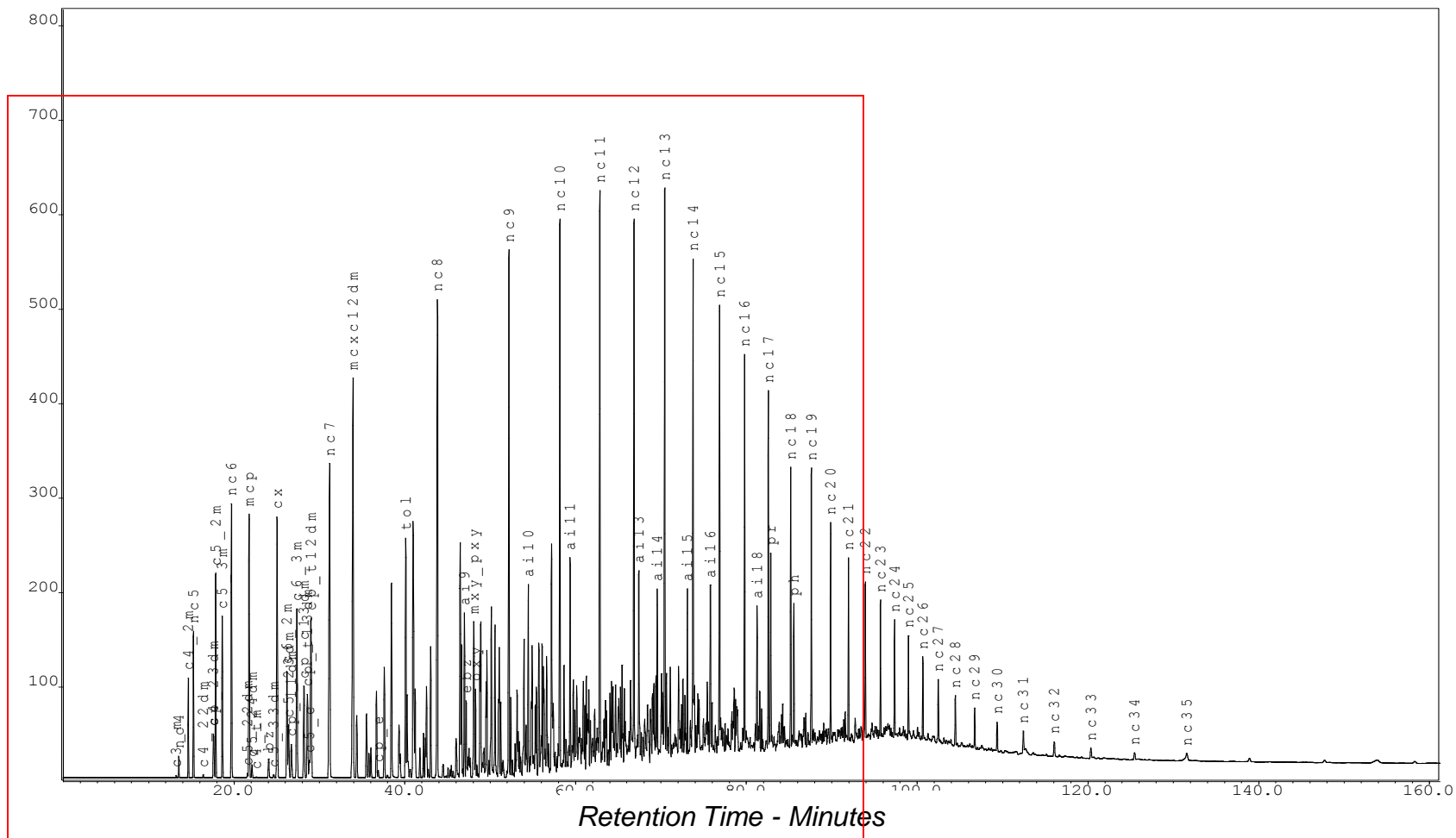
Sample UH-00039-001



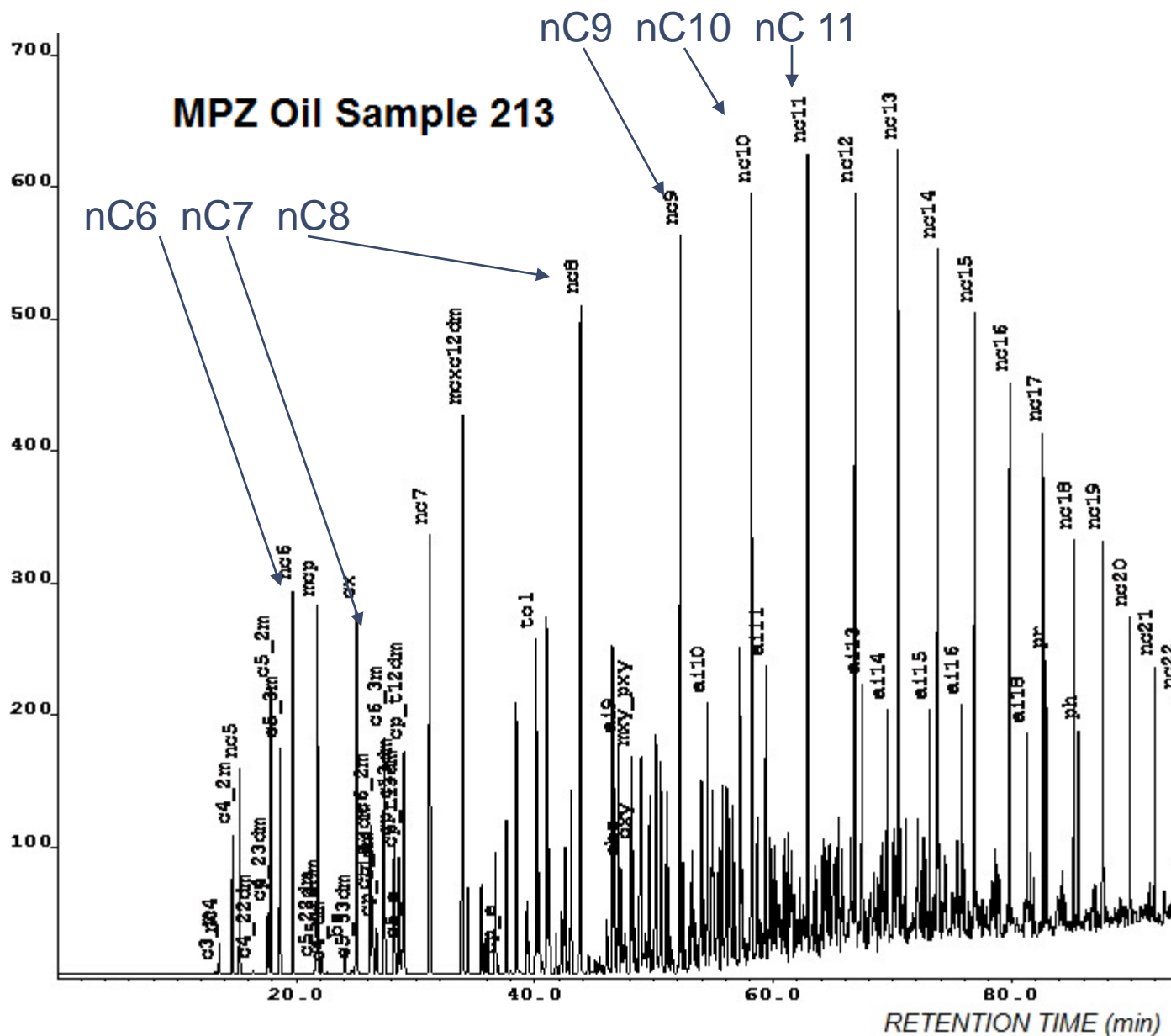
File: 11G10147.D\FID28.CH  
Date & Time: 7/22/11 1:49:31 PM

Acquired with corporate support from

**LEGADO**  
resources

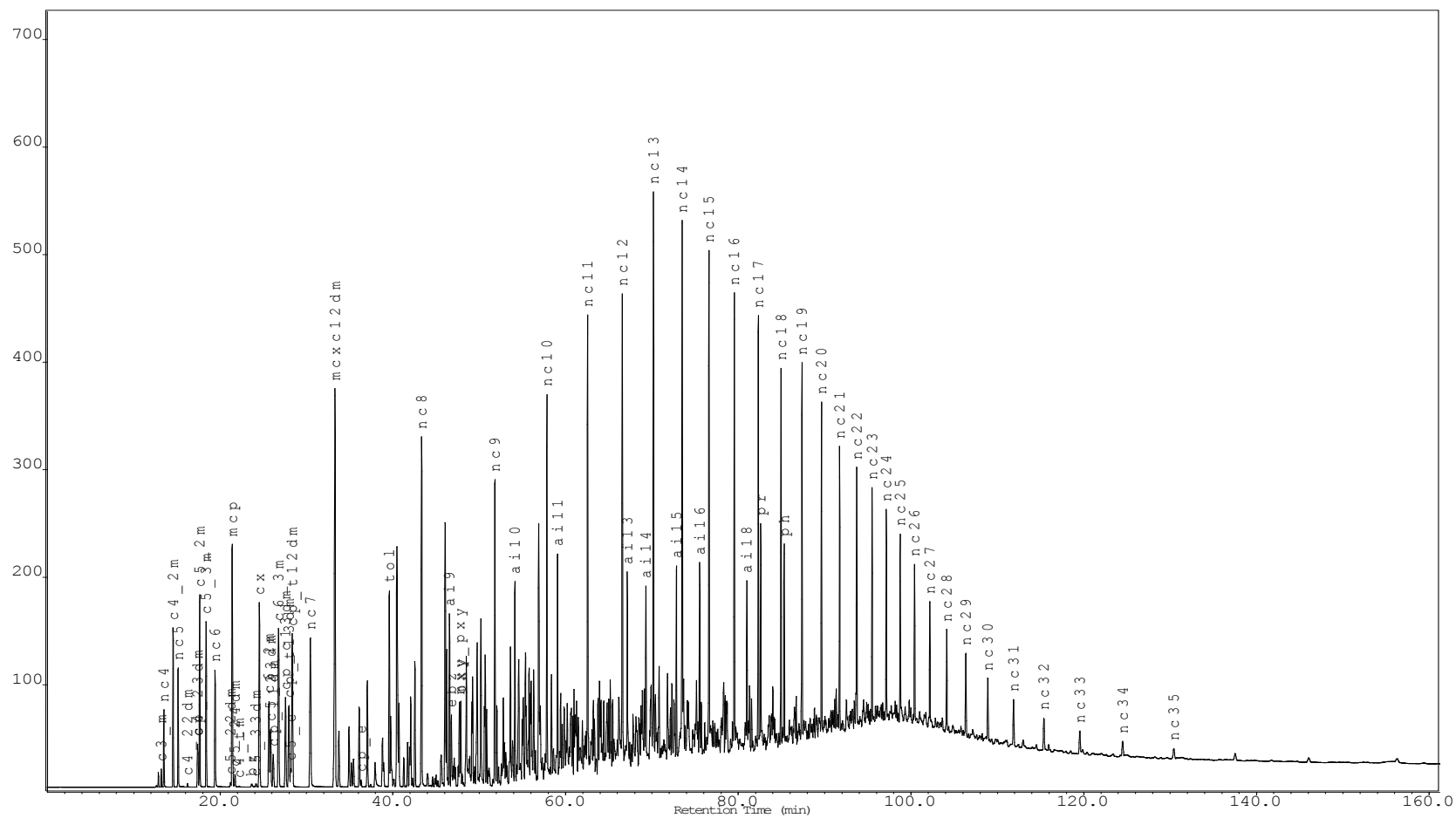


# MPZ Oil GLSAU

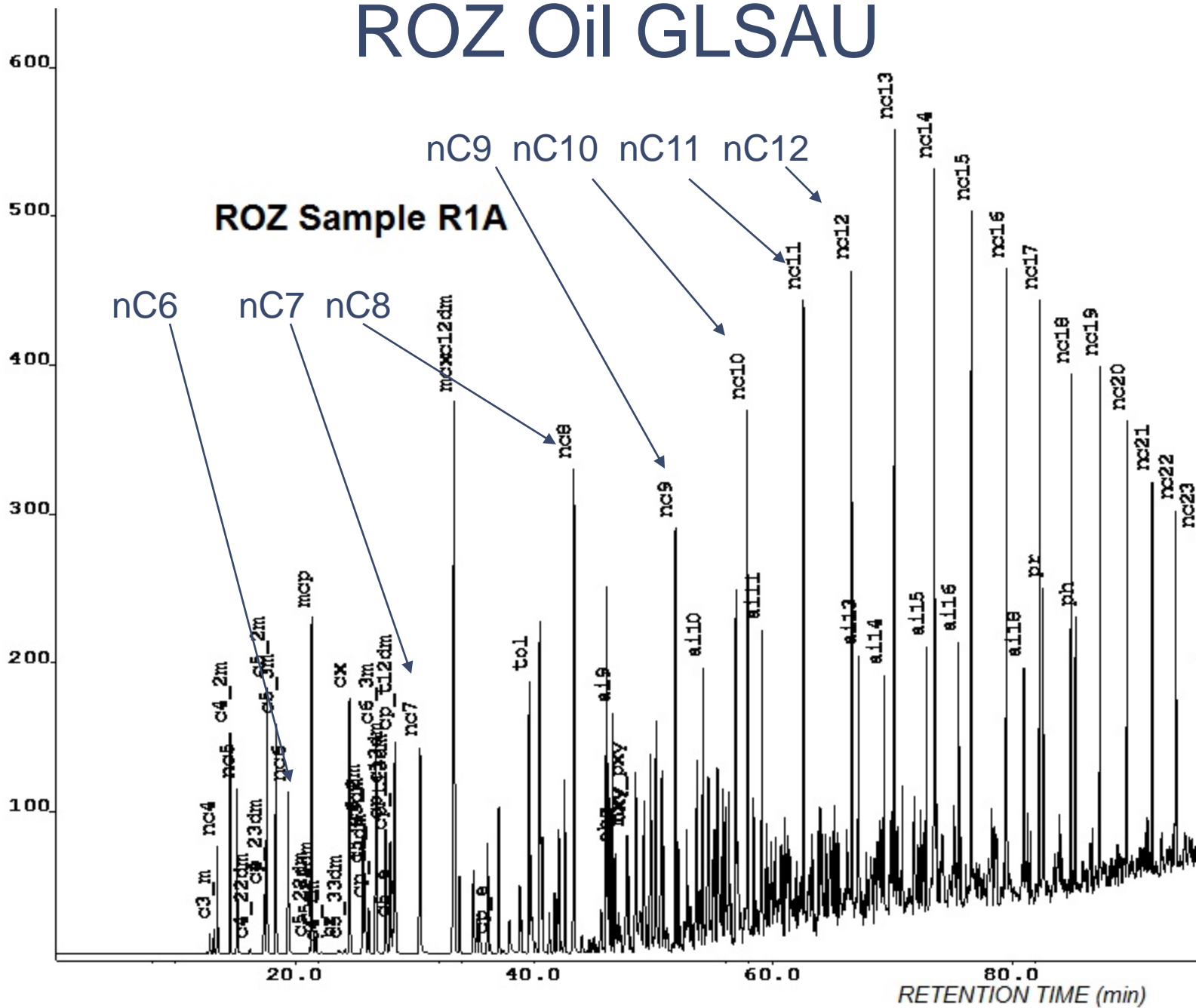


# ROZ Oil GLSAU GC Results

## Sample R1A



# ROZ Oil GLSAU



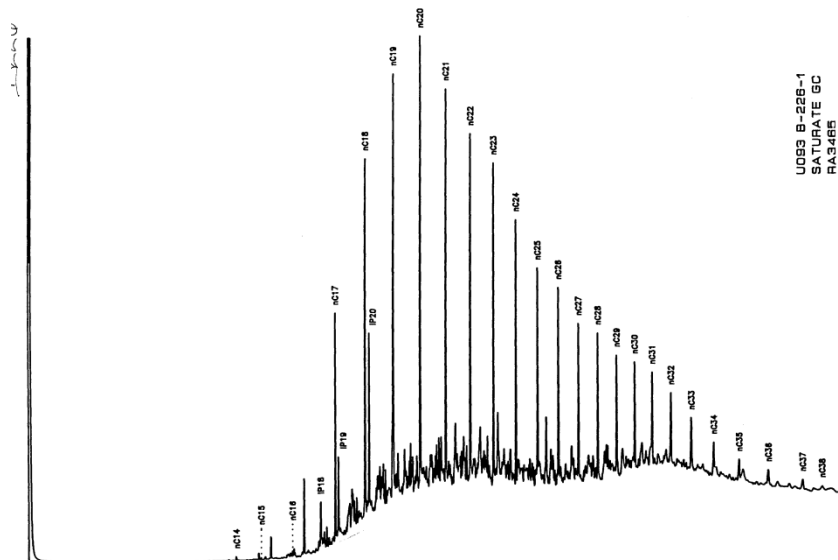
Another Basin,  
Another (heavier) Oil



# Bighorn Basin, Wy Tensleep Oil

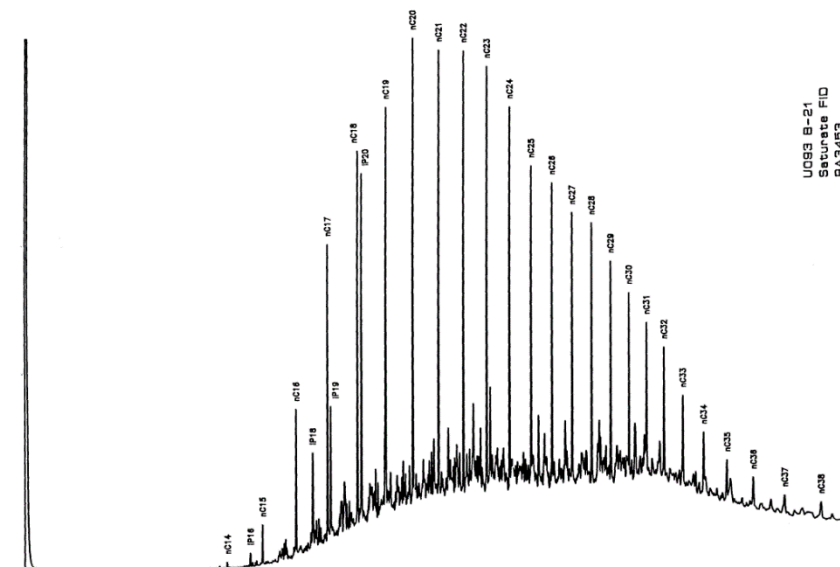
## Oil Properties are similar in TZ/ROZ and MPZ\*

### MPZ Reservoir Oil

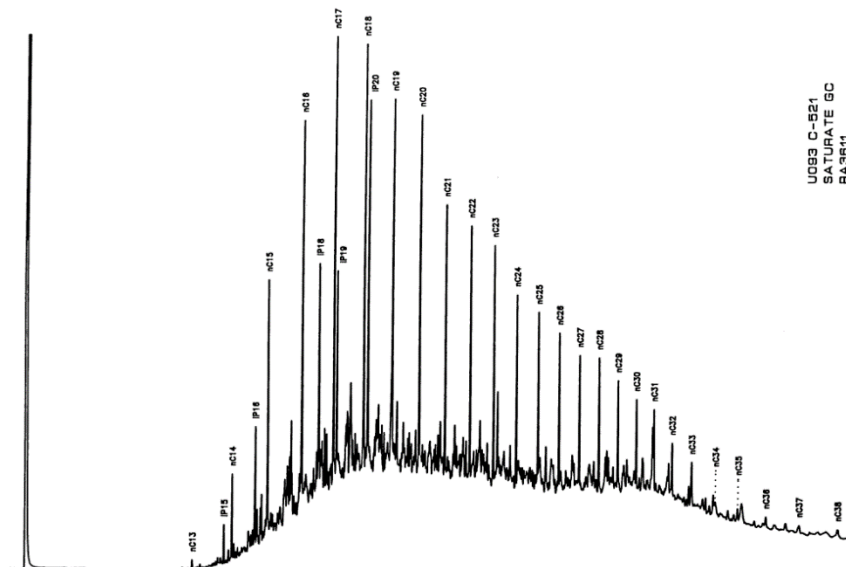


U093 B-228-1  
SATURATE GC  
RA3485

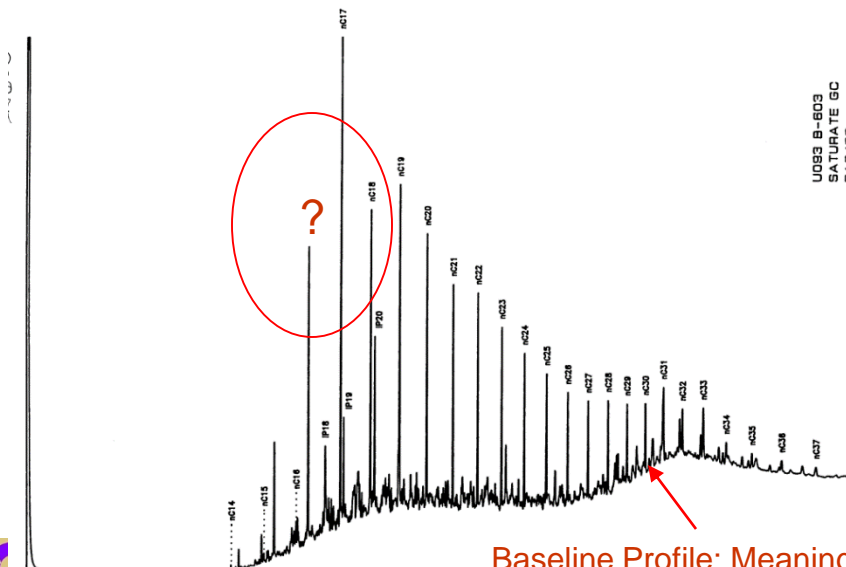
### From Non-productive Wells (ROZs?)



U093 B-21  
SATURATE FID  
RA3453



U093 C-521  
SATURATE GC  
RA3611



U093 B-603  
SATURATE GC  
RA3469

Baseline Profile; Meaning?

# Needed Work

- Get Oil Samples from Various Vertical Positions in the Type 3 ROZs
- Get Oil Compositions Paying Close Attention to Miscible-critical Components (C-5 to C-20)
- Get and Analyze Oils from Type 1 and 2 ROZs to Compare to MPZ Oils
- Look at Both Microbial and Diffusivity Explanations for HC Component Reductions



# What Do We Know About Type 3 ROZ Water?

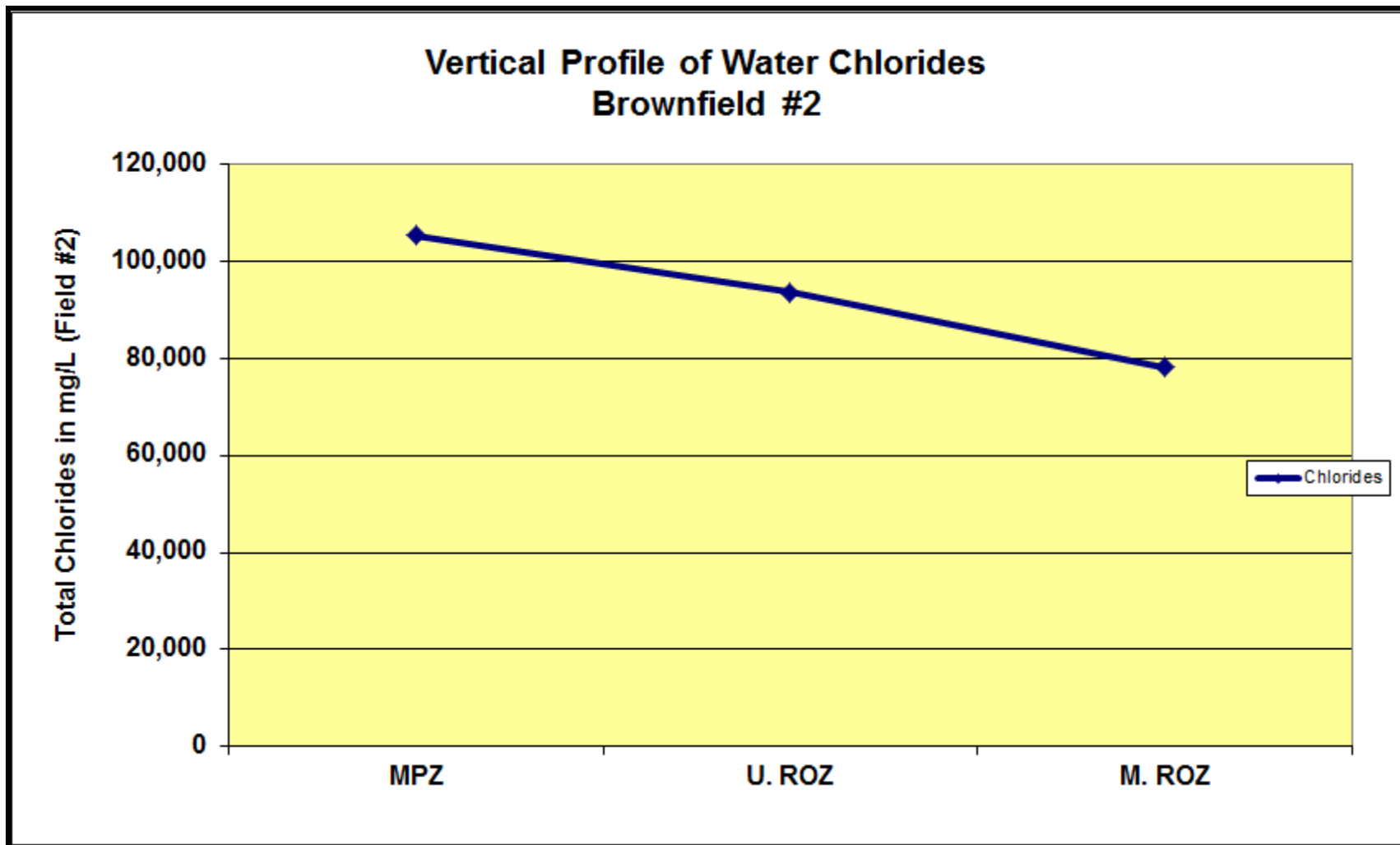
# PB Field #1

**Table 3. ROZ Oil, H<sub>2</sub>O and CO<sub>2</sub> Properties at 2000 psia and 105 °F \***

Fluid	Viscosity cP	Density lb/cft	CO <sub>2</sub> Injection		CO <sub>2</sub> Solubility scf/stb			IFT dynes/cm
			Swelling	Viscosity	H <sub>2</sub> O	Brine	ROZ Oil	
Oil	1.2119	46.4042	77%	0.477			1600	} < 0.2
CO <sub>2</sub>	0.0564	43.7874						
Water	0.7179	62.1753	6%	0.706	176	50		

\* Ref: SPE 133089, Honarpour, M.M. et al (2010), Rock-Fluid Characterization for Miscible CO<sub>2</sub> Injection: Residual Oil Zone, Seminole Field, Permian Basin

# PB Field #2 – Water Salinities



# Big Horn and Other Basins

## *Water Salinities*

- Water Can Actually be “Fresh”

These Type 3, Laterally Flushed, ROZs can be thought of in a Pore Volume Flushing Context

- In our First RPSEA Report (West Side of the Central Basin Platform), we Modeled and Calculated the San Andres Hydrodynamic Flushing at 17-46 Total Pore Volumes (15 million years) using DST\*-derived Permeabilities

\* Drillstem Test

# Proximity to Source Waters

## *For Type 3 ROZs*

- The Closer to the Source and
- The Higher the Formation Permeability

Then The Greater the Pore Volume Flushing and Fresher the Water

- Does that Affect the Residual Oil Saturation? That is, is it Like a Low Salinity Water Flood?
- Should We Expect Variable Waters Even in a Project Area (Vertically, Horizontally)?

## Section 4

# The Permian Basin ROZ Resource (San Andres Formation)

*Our report on this is pending and under review at RPSEA and DOE)*

*Vello Kuuskraa*  
*Advanced Resources*  
*International*



# The Three Residual Oil Zone Resource Studies to Date

- 2006 - Brownfields Beneath 56 fields  
(45 San Andres/Grayburg Fields)
- 2014 – Four County Greenfield ROZ  
Study (All San Andres)
- 2015 – Eight County Greenfield ROZ  
Study (All San Andres)

# Summary of ROZ Brownfield Study

(2006)

Field/Unit	TZ/ROZ OOIP (BB)	No. of Fields	No. of MPZ Fields with CO2- EOR Projects	No. of Fields with TZ/ROZ CO2-EOR Projects
1. Northern Shelf Permian Basin (San Andres)	13.2	13	5	1
2. North Central Basin Platform (San Andres/Grayburg)	2.6	6	2	1
3. South Central Basin Platform (San Andres/Grayburg)	7.9	16	5	0
4. Horseshoe Atoll (Canyon)	2.9	10	4	2
5. East New Mexico (San Andres)	4.1	11	2	0
Total	30.7	56	18	4



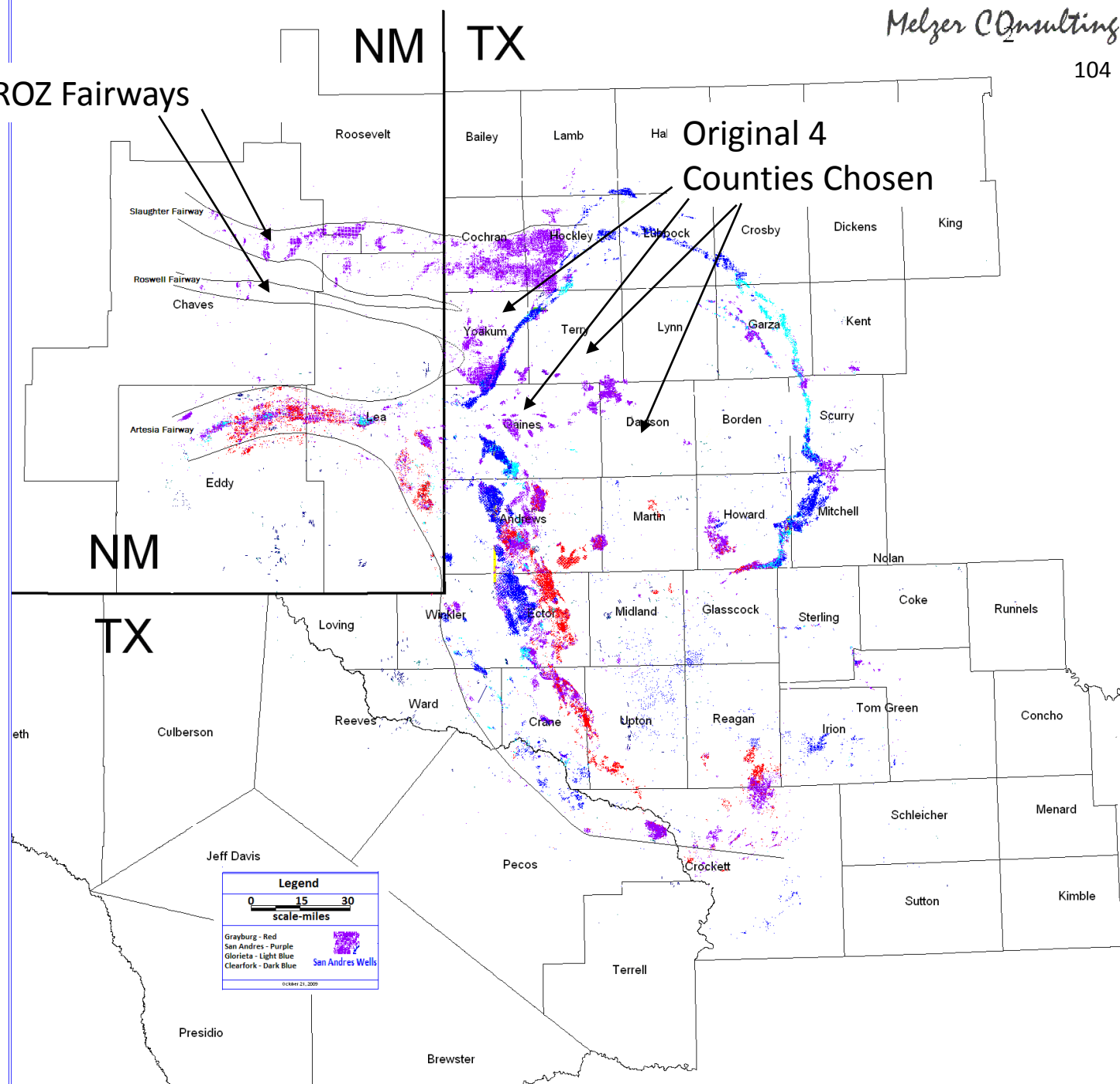
# Brownfield Recoverable Resources

Field/Unit	Total CO <sub>2</sub> -EOR (BB)	MPZ CO <sub>2</sub> -EOR (BB)	ROZ CO <sub>2</sub> -EOR (BB)
1. Northern Shelf Permian Basin (San Andres)	8.3	2.8	5.5
2. North Central Basin Platform (San Andres/Grayburg)	1.5	0.6	0.9
3. South Central Basin Platform (San Andres/Grayburg)	4.6	1.7	2.9
4. Horseshoe Atoll (Canyon)	2.7	1.4	1.3
5. East New Mexico (San Andres)	1.7	0.4	1.3
Total	18.8	6.9	11.9

# RPSEA II Study Foundation: San Andres Fairway Mapping

November 2015

Early San  
/ San Andres ROZ Fairways  
Fairway  
Mapping  
(Circa 2009)



## In-Place San Andres ROZ "Fairway" Resources: Four-County Area of West Texas

County	In-Place Resources		
	Total	Higher Quality	Lower Quality
	(B Bbls)	(B Bbls)	(B Bbls)
<b>Gaines</b>	45.5	35.4	10.1
<b>Yoakum</b>	20.7	16.1	4.6
<b>Terry</b>	17.9	10.6	7.3
<b>Dawson</b>	27.8	14.6	13.2
<b>Total</b>	<b>111.9</b>	<b>76.7</b>	<b>35.2</b>

Source: Advanced Resources International, 2015.

# Also Performed a Recoverable Resource Estimate and Checked Against First Draft of KM's "Tall Cotton" Recoverables

**Exhibit 7.3.3 (EX-3) Comparison of Gaines County Volumetric San Andres ROZ "Fairway" Reservoir Properties: Tall Cotton ROZ "Fairway", Seminole Oil Field ROZ, and This Study's Partition #3**

Volumetric Reservoir Properties	Seminole Oil Field ROZ <sup>1,2</sup>	"Tall Cotton" ROZ "Fairway" <sup>3</sup>	This Study Partition #3		
	(ROZ "1" Only)	(ROZ "1" & ROZ "2")	ROZ "1"	ROZ "2"	Total
<b>Gross Pay (feet)</b>	246	540	244	248	492
<b>Net Pay (feet)</b>	197	450	208	224	432
<b>Porosity (%)</b>	12.8%-15%	12%	10.2%	9.7%	10%
<b>Oil Saturation (%)</b>	32%	35% to 50%	36%	36%	36%

<sup>1</sup>Honarpour, M., 2010. <sup>2</sup>Bush, J., 2001. <sup>3</sup> Railroad Commission of Texas, 2014.

Source: Advanced Resources International, 2015.

What portion of this in-place San Andres ROZ "fairway" oil resource can be mobilized

# Recoverable Resources

## (4-County Study)

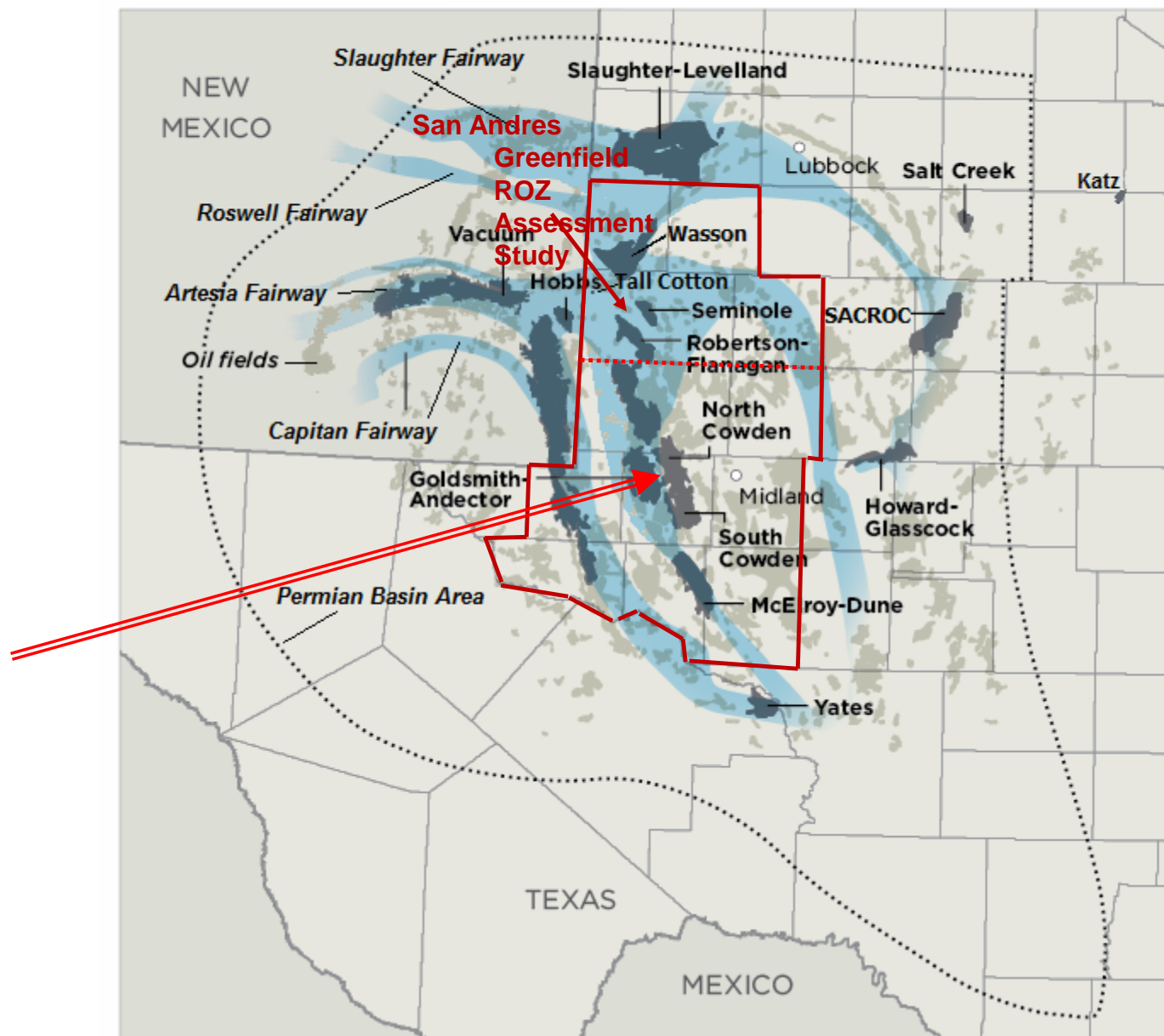
**Exhibit 7.3.4 (EX-4) Technically Recoverable San Andres ROZ "Fairway" Resources:  
Four-County Area of West Texas**

County	Technically Recoverable Resources	
	(B Bbls)	(% OIP)
Gaines	12.1	27%
Yoakum	4.9	24%
Terry	3.2	18%
Dawson	5.5	20%
<b>Total</b>	<b>25.7</b>	<b>23%</b>

Source: Advanced Resources International, 2015.

# Expanded OIP Resource Study to 8 More Counties (2015)

# Residual Oil Zone Fairway Mapping with Superimposed Major Permian and Pennsylvanian Oilfields and Showing the First Pure ROZ Greenfield ROZ CO<sub>2</sub> Project

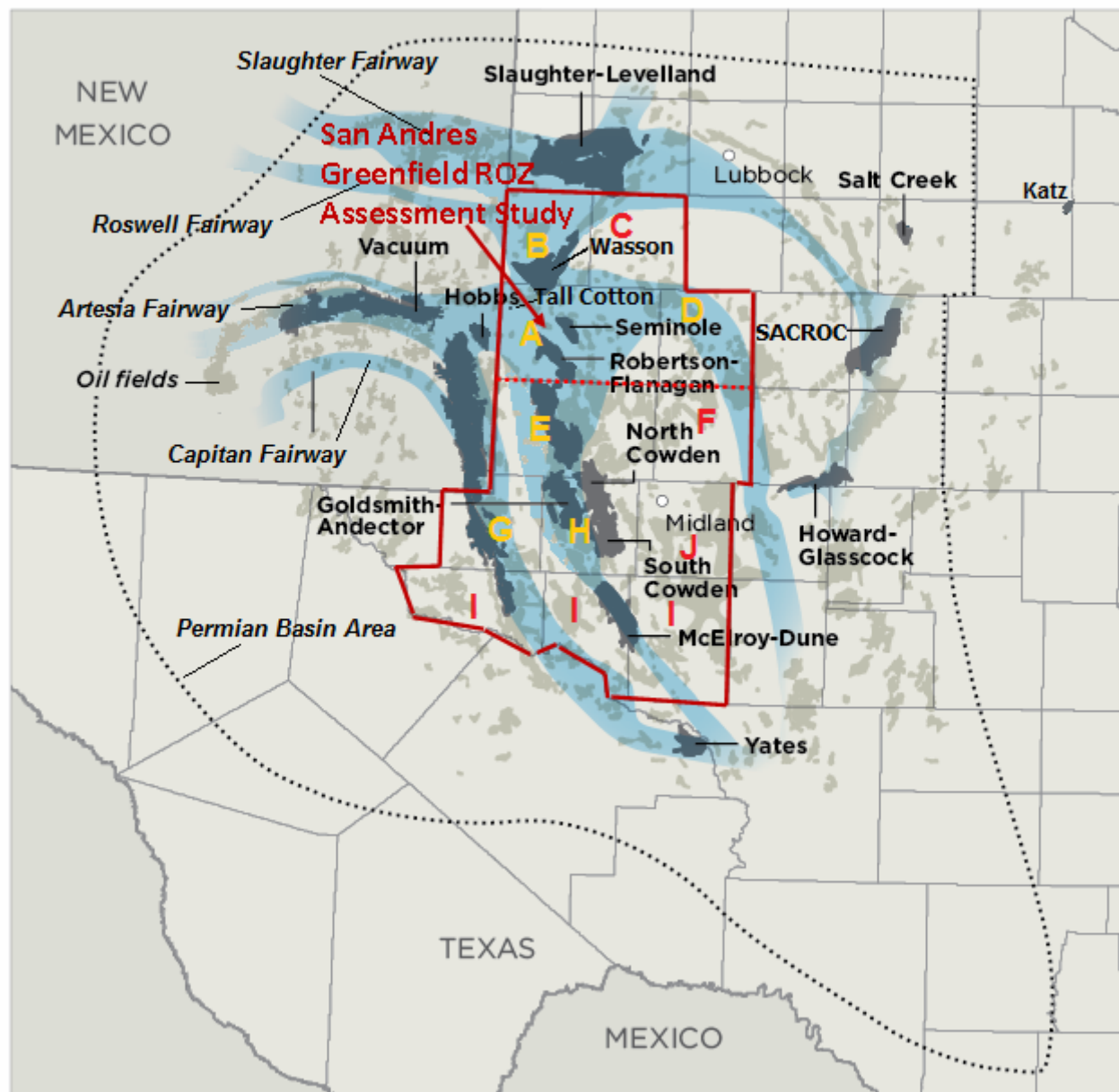




# Residual Oil Zone Fairway Mapping with Superimposed Major Permian and Pennsylvanian Oilfields and Showing the First Pure ROZ Greenfield ROZ CO<sub>2</sub> Project

## 12-County ROZ Study (ARI)

2014 (4-county) and  
2015 (8-county)



# 12-County Greenfield ROZ Resources

Co. Designation	County by County San Andres Greenfield ROZ Study (LSM, ARI, RPSEA II/DOE)									
	PB Texas	County mi^2	County (Acres)	ARI Est ROZ Acreage (Acres)	(G/E) Calculated %age of County	ARI TOTAL ROZ OIP Million bbls	ARI HIGHER QUAL ROZ OIP, Million bbls	(I/G) Estimated (Calc'd) Average Co-wide TOT ROZ bbls/AC	(J/G) Estimated Average Co-wide HQ ROZ bbls/AC	ARI Technically Recoverable Million bbls
A	Gaines	1,503	961,920	858,000	89%	45,500	35,400	53,030	41,259	12,100
B	Yoakum	800	512,000	421,000	82%	20,700	16,100	49,169	38,242	4,900
C	Terry	891	570,240	549,000	96%	17,940	10,600	32,678	19,308	3,182
D	Dawson	902	577,280	562,000	97%	27,770	14,610	49,413	25,996	5,486
E	Andrews	1501	960,640	657,600	68%	37,130	31,230	56,463	47,491	NC
F	Martin	916	586,240	353,700	60%	6,740	4,800	19,056	13,571	NC
G	Winkler	841	538,240	342,800	64%	9,470	7,980	27,625	23,279	NC
H	Ector	902	577,280	348,300	60%	6,950	5,500	19,954	15,791	NC
I	Upton	1242	794,880							
I	Crane	786	503,040	760,000	41%	19,180	8,670	25,237	11,408	NC
I	Ward	836	535,040							
J	Midland	902	577,280	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Running PB Texas Totals				4,856,420		191,715	134,890	36,958 Average	26,261 Average	25,668

## ***Section 5***

# ON-GOING RESIDUAL OIL ZONE DEMONSTRATION PROJECTS

ROZ Seminar  
CO<sub>2</sub> Conference  
December 2015

Bob Trentham & Steve Melzer

## Section 5a

# CO<sub>2</sub> EOR Case Histories

*Bob Trentham*

# There are Two Categories of Projects Currently Exploiting the ROZ

*(This Section has an Engineering Emphasis)*

- a. EOR Exploitation (currently limited to CO<sub>2</sub> EOR and the Permian Basin)
- b. Depressuring the Upper ROZ (DUROZ) also Occasionally Referred to as Depressuring EOR

## *Subsection 5a*

# ON-GOING CO<sub>2</sub> EOR RESIDUAL OIL ZONE DEMONSTRATION PROJECTS

ROZ Seminar  
CO<sub>2</sub> Conference  
December 2015

Bob Trentham



# Permian Basin Stratigraphic Column, Cumulative Production to Date & Estimated OOIP

SYSTEM	SERIES	STRATIGRAPHIC UNIT
PERMIAN	Ochoan	Dewey Lake
		Rustler
		Salado
		Castile
	Guadalupian	Capitan
		Tansill
		Yates •
		Seven Rivers •
		Goat Seep
		Queen •
PENNSYLVANIAN	Leonardian	Grayburg
		San Andres ●
		Glorieta
	Wolfcampian	Sprayberry
		Clear Fork
		Dean •
		Wolfcamp •
		Cisco •
		Canyon
		Strawn •
MISSISSIPPIAN		Bend •
		Mississippian •
DEVONIAN		Devonian •
SILURIAN		Fuselman •
ORDOVICIAN	upper	Montoya •
	middle	Simpson •
	lower	Ellenburger ●
CAMBRIAN		

Relative production • → ●

## Cumulative Production

### Permian Basin

32 BBO  
98 TCF

### San Andres

12 BBO  
2 TCF

## Estimated OOIP

### Permian Basin

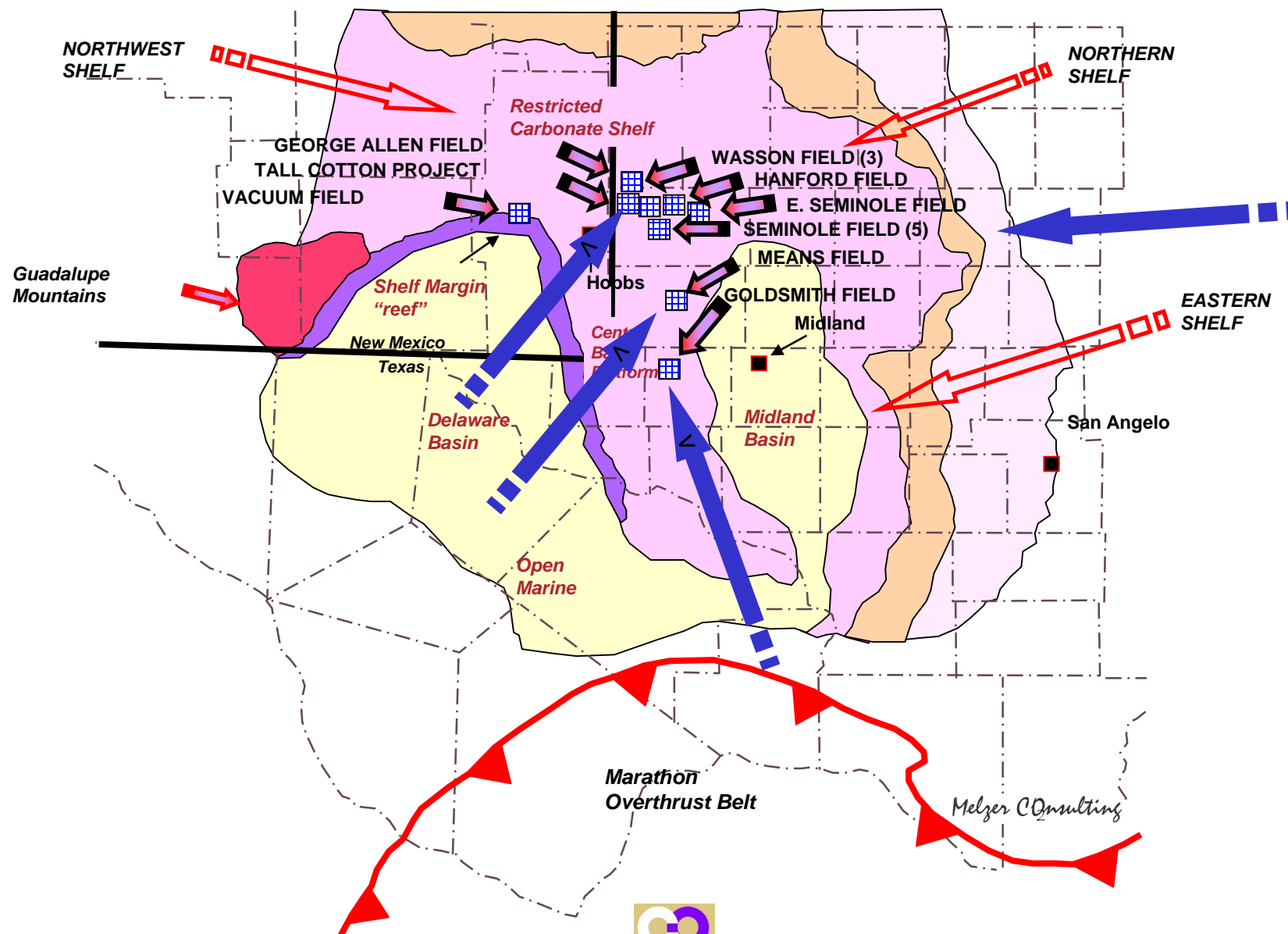
100 BBO\*\*

### San Andres

40 BBO\*\*

\*\* The "Old" OOIP #; does not include the New Shales' and ROZs' OOIP

# MIDDLE SAN ANDRES FORMATION PALEOGEOGRAPHY with Location of Industry Documented ROZ Zones/Fields





# The List of On-going ROZ CO<sub>2</sub> EOR Projects

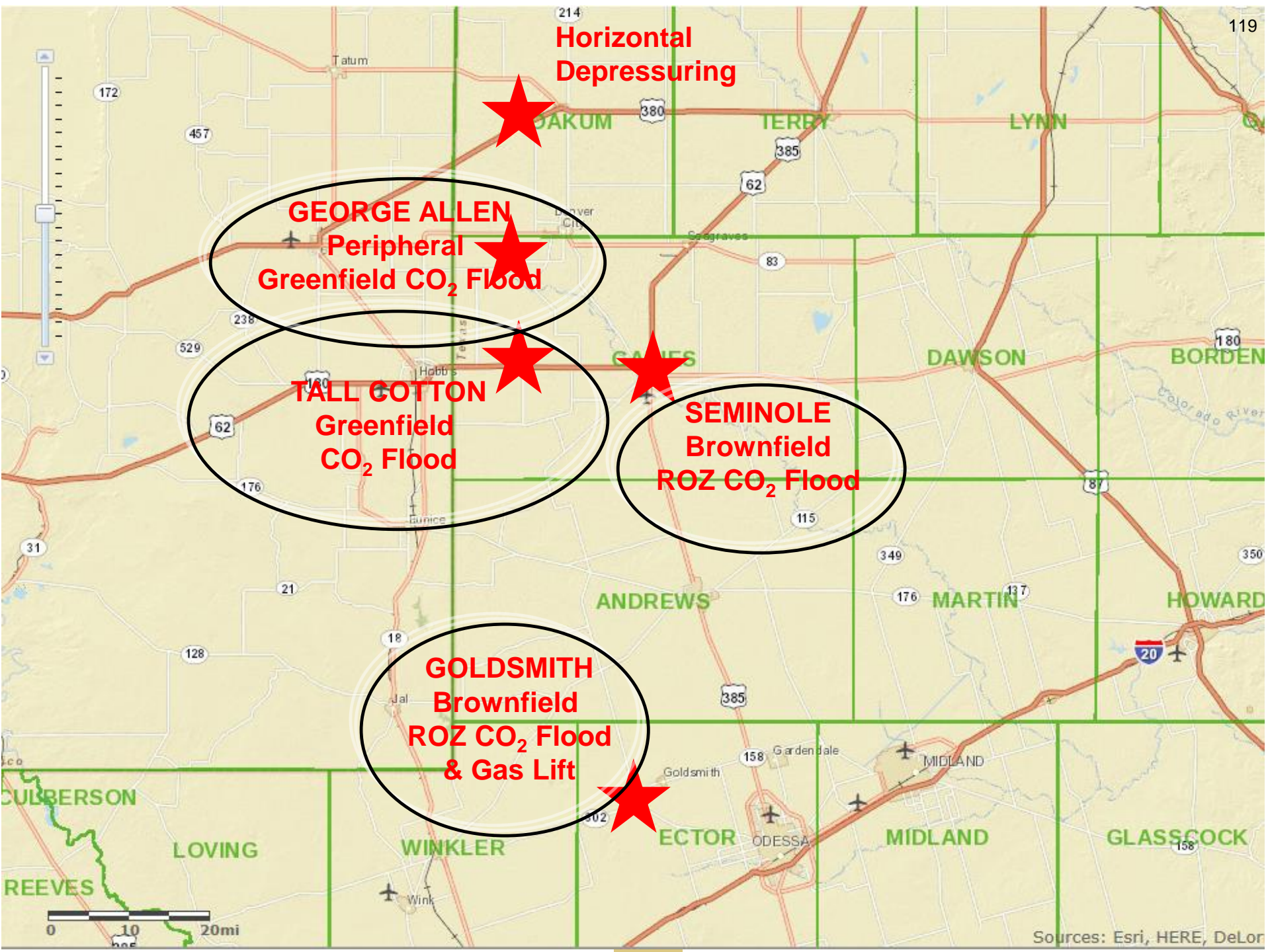
*Melzer Consulting*  
as of June 2015

## ON-GOING ROZ CO<sub>2</sub> EOR PROJECTS IN THE PERMIAN BASIN REGION OF THE U.S.

Type and operator	Field	State	County	Top MPZ Depth, (ft)	Pay zone	Lithology	MPZ Start Date	ROZ Start Date	Strategy
Active CO <sub>2</sub> miscible									
1 Chevron	Vacuum San Andres Grayburg Unit	NM	Lea Co.	4,550	San Andres	Dolo.	2007	2007	Commingle
2 Fasken	Hanford	Tex.	Gaines	5,500	San Andres	Dolo.	7/86	8/09	Commingle
3 Hess	Seminole Unit-ROZ Phase 1	Tex.	Gaines	5,500	San Andres	Dolo.	7/83	7/96	Commingle
4 Hess	Seminole Unit-ROZ Phase 2	Tex.	Gaines	5,500	San Andres	Dolo.	7/83	4/04	Deepen (Dedicated*)
5 Hess	Seminole Unit-ROZ Stage 1 Full Field Dev	Tex.	Gaines	5,500	San Andres	Dolo.	7/83	10/07	Commingle
6 Hess	Seminole Unit-ROZ Stage 2 Full Field Dev	Tex.	Gaines	5,500	San Andres	Dolo.	7/83	5/11	Commingle
7 Hess	Seminole Unit-ROZ Stage 3 Full Field Dev	Tex.	Gaines	5,500	San Andres	Dolo.	7/83	7/13	Commingle
8 Kinder Morgan CO <sub>2</sub> C	Goldsmith-Landreth Unit	Tex.	Ector	4,200	San Andres	Dolo.	8/09	8/09	Commingle
9 Kinder Morgan CO <sub>2</sub> C	Tall Cotton Pilot Project	Tex.	Gaines	5,250	San Andres	Dolo.	n/a		Green Field ROZ
10 Occidental	Wasson Bennett Ranch Unit	Tex.	Yoakum	5,250	San Andres	Dolo.	6/95	2000	Commingle
11 Occidental	Wasson Denver Unit	Tex.	Yoakum	5,200	San Andres	Dolo.	4/83	1995**	Commingle
12 Occidental	Wasson ODC	Tex.	& Gaines	5,200	San Andres	Dolo.	Nov-84	2005?	Commingle
13 Trinity CO <sub>2</sub>	George Allen (BF&GF) ***	Tex.	Yoakum	4,900	San Andres	Dolo.	12/12	2012	Deepen&Drill
14 Tabula Rasa	East Seminole	Tex.	Gaines	5,400	San Andres	Dolo.	1/13	1/13	Commingle
15 XTO/ExxonMobil	Salt Creek	Tex.	Kent	6,300	Canyon Reef	LS	Jun-05	1996	Commingle
16 XTO/ExxonMobil	Means	Tex.	Andrews	4,500	GrBrq/San Andres	Dolo.	Nov-83	1/12	Commingle

\*\*\* BF = 'brownfield' (requires wells deepening);

GF = 'greenfield' (requires new wells)



**Horizontal  
Depressuring**

**GEORGE ALLEN  
Peripheral  
Greenfield CO<sub>2</sub> Flood**

**TALL COTTON  
Greenfield  
CO<sub>2</sub> Flood**

**SEMINOLE  
Brownfield  
ROZ CO<sub>2</sub> Flood**

**GOLDSMITH  
Brownfield  
ROZ CO<sub>2</sub> Flood  
& Gas Lift**

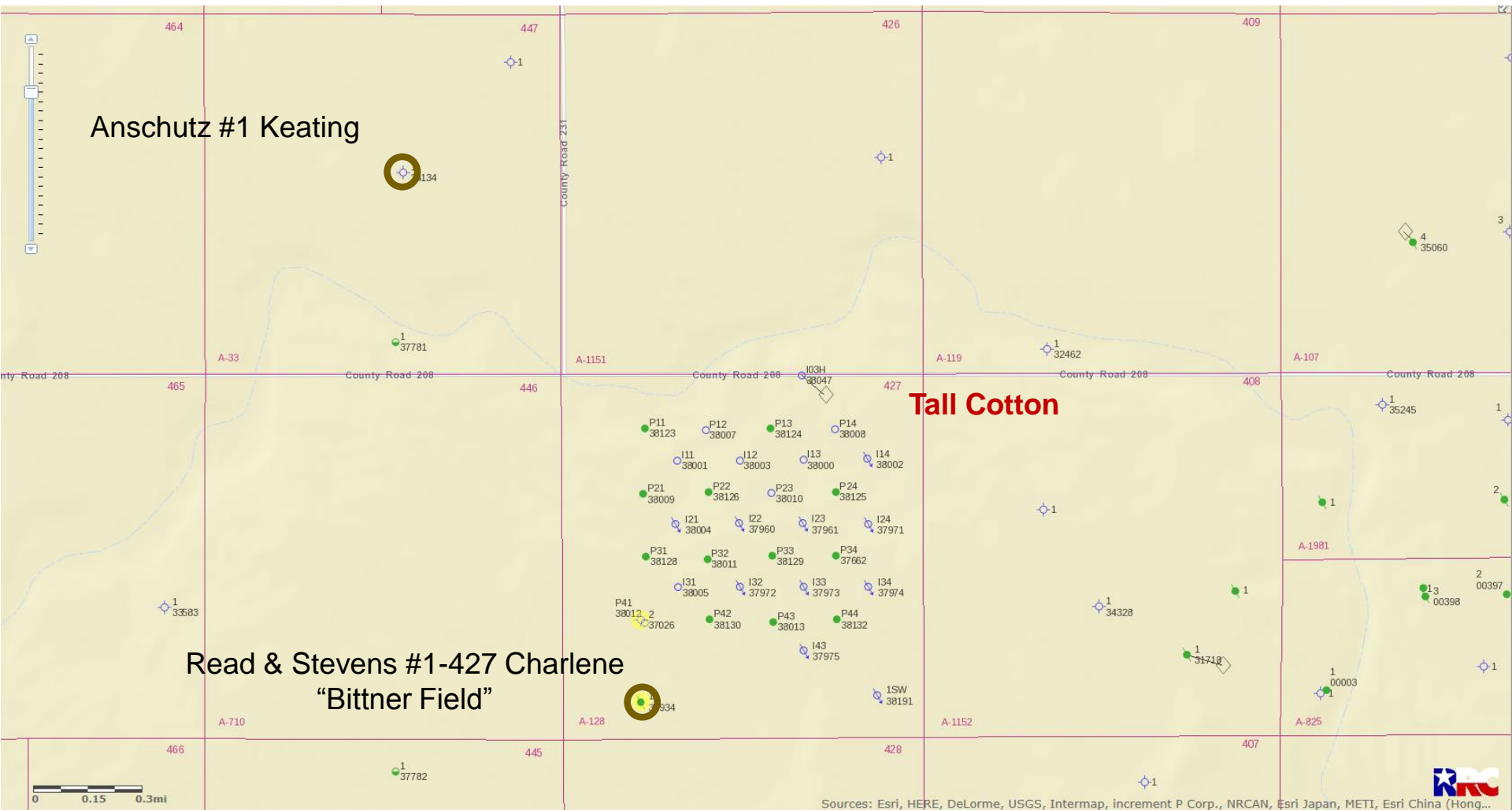
# **SEMINOLE FIELD**

THE “GOLD STANDARD” OF ROZ PROJECTS





2 wells, the #1 Keating and the #1-427 Charlene, provided the information necessary to establish the presence of a significant Greenfield ROZ in the area.



Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong...

*Subsection 5b*

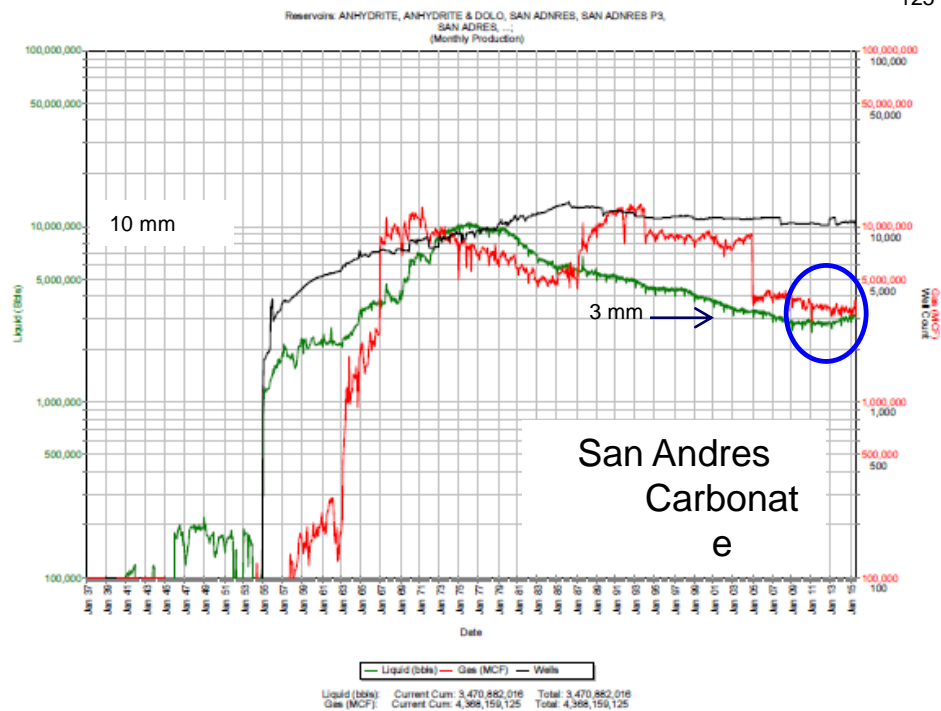
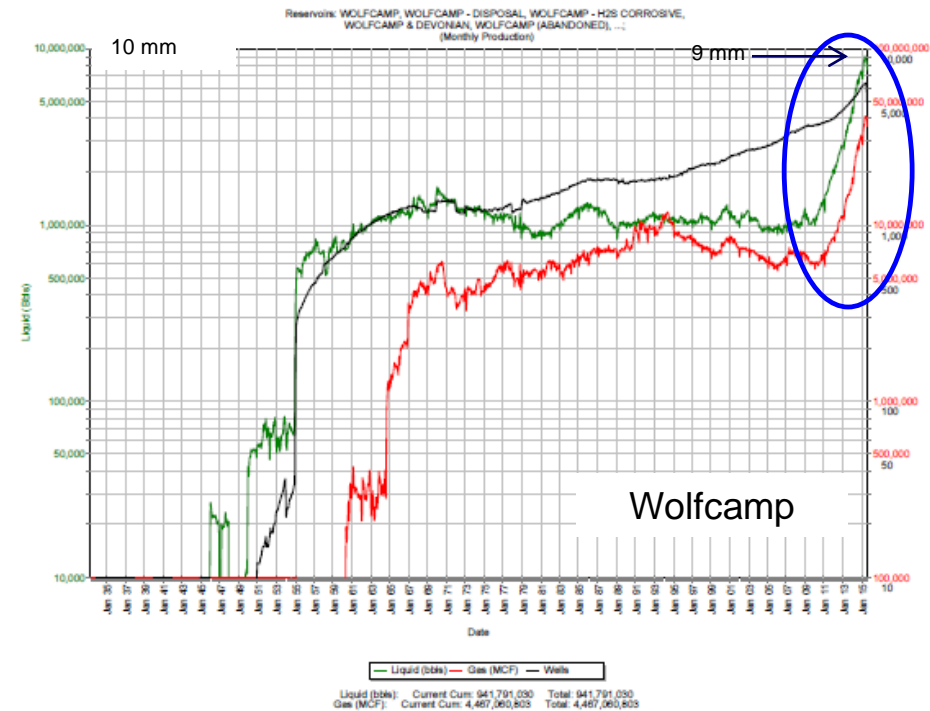
# EXPLOITING THE RESIDUAL OIL ZONE VIA DEPRESSURING

ROZ Seminar  
CO<sub>2</sub> Conference  
December 2015

Steve Melzer



# Has the Permian Basin Entered a Second and New Era of Horizontal Well Production?



## CONCLUSIONS

- Wolfcamp Oil has effectively caught up with San Andres Oil Production
- Wolfcamp Gas Blows away San Andres Gas (40 bcfd to 3)
- We Would Suspect the NGL Production Story is a Very Similar One  
BUT.....is there more to this story?



# Other Critical Factors to Consider

- The Carbonate Formation Decline Curve has Historically been very Gentle (4-5% per year) - as witnessed on the last slide
- The Shale Decline Curves are Very Steep Creating the Need to Keep Drilling at a Rapid Pace
- The \$100/bbl Oil Era Allowed Technology to Leap Forward; \$40-50/bbl Oil will still have Sweetspots to Exploit - especially in the PB
- Is There Anything New with the Carbonates? Could they be a Hybrid between the Gentler Decline Curve and Big Quick Returns on Investments that the Shales Give?

# It is Very New but There is Indeed More to the Story

- A New Horizontal Resource Play (Depressuring the Upper ROZ) in the San Andres has Just Entered the Picture and Shows Promise of Adding Another Dimension to the PB Production Story as Time Moves Forward
- How Big is this New Play?
- What are its Characteristics?
- Does This have Scalability to Other Part of the U.S. and World?

# Insights on An Overlooked Production Mechanism and Demonstration Case Histories:

*A New and Exciting San Andres Residual Oil Zones Oil Play - Depressuring the Upper ROZ (DUROZ)\**

*December 2015*

*\* Can Also Be Referred to as Depressuring EOR (DEOR)*



# Where to Start?

Much has Been Learned About Residual  
Oil Zones in the Last Decade

Almost all of it from Work Here in the Permian Basin

# Current Thinking on ROZ's

Oil and gas industry thinking has historically believed that residual (immobile) oil can only be recovered using enhanced recovery techniques. The fastest growing technique uses carbon dioxide-enhanced oil recovery (CO<sub>2</sub> EOR) and is currently being used to recover oil from ROZs in 15 different projects as you just saw.

And....these ROZs are Predominately Oil Wet with Large Immobile Oil Targets

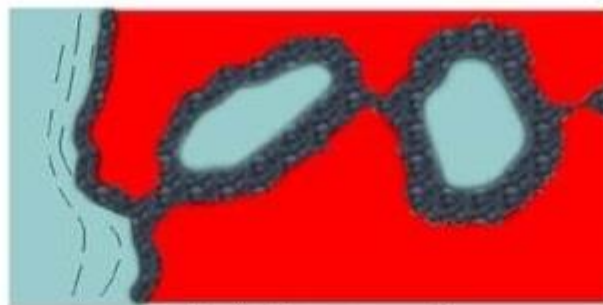
Are EOR injection projects the only way?

# An Exciting New Strategy for ROZ's

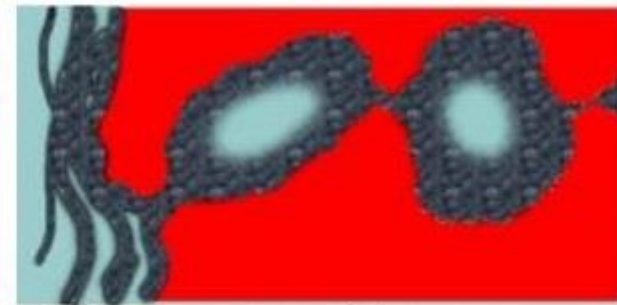
- Two companies, drilling and completing horizontal wells in Yoakum County, Tx, have very recently found that they can make a ROZ productive without using an injectant (classic EOR). We believe that they did not originally understand exactly what was controlling the production but, nonetheless, their results are exciting and speak for themselves.
- As of the Present, over 30 wells have been drilled and, after roughly a month of 100% water production, all showed climbing oil cuts and, at the 90<sup>th</sup> day of production, between 200-300 bbls/day.

# How Does ROZ Depressuring Work?

The ROZs have Oil Affixed to the Rock Surfaces and, if that Oil Has Gas in it, Depressuring Releases Some of the Oil and Entrained Gas



Bubbles swell



Oil Seeps out of the pores. ...

...and into the flowstream to flow to the well. Lots of water is produced to accomplish the depressuring

*Melzer Consulting*

# Mapping of Active Major CO<sub>2</sub> EOR Projects in the Permian Basin and Residual Oil Zone Fairways and Showing the First Pure ROZ Greenfield ROZ CO<sub>2</sub> Project

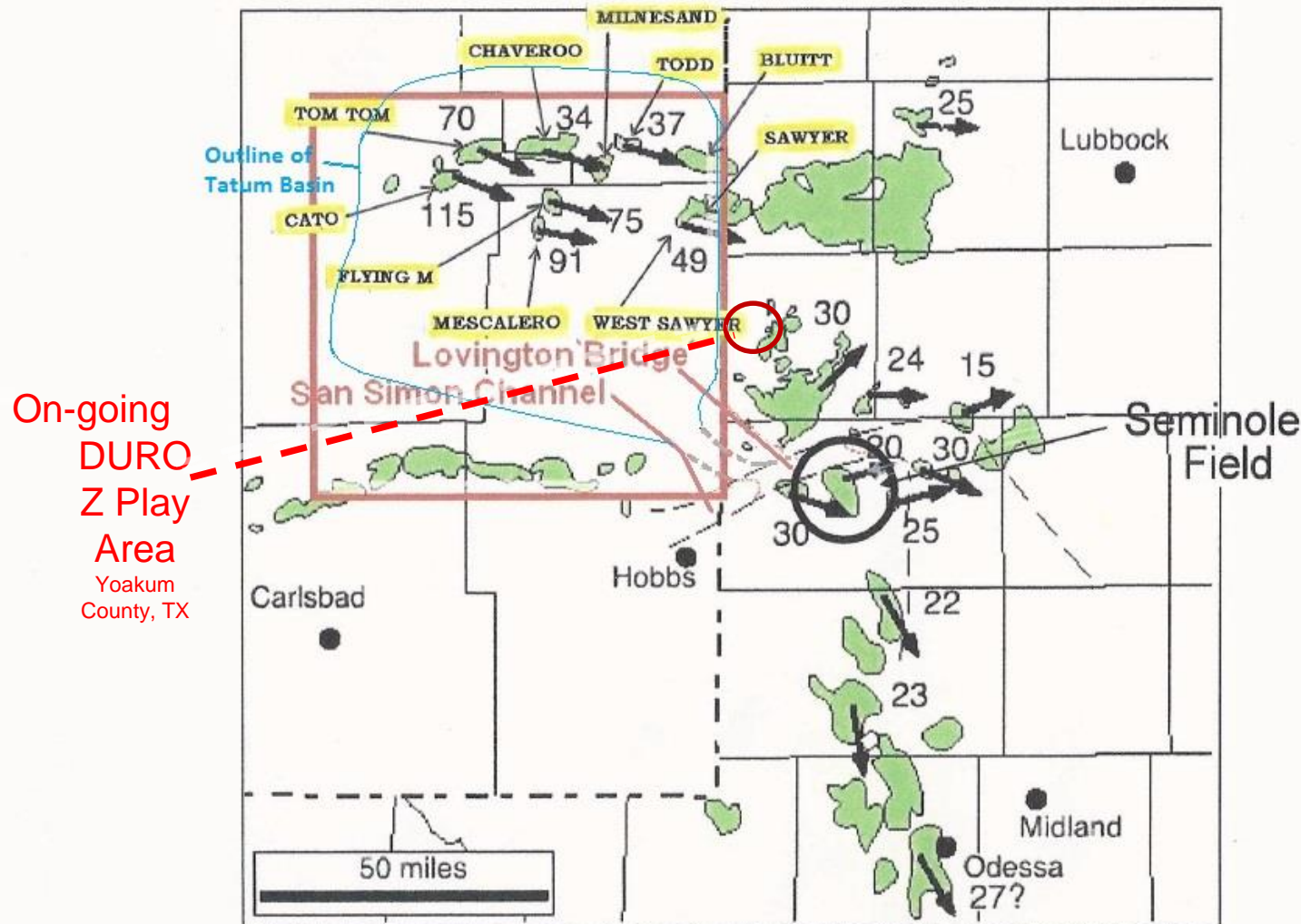
## The Permian Basin

We are looking at this Area in particular





# Distribution of Tilted Oil-Water Contacts in the Northern Shelf & Central Basin Platform Areas of the Permian Basin\*



\* Adapted from Alton Brown, WTGS Fall Symposium (2001)  
and

"San Andres Oil East of the Pecos," Gratton, J.F., & LeMay,  
William J., 22nd Mtg, NM Geol Society, Hobbs, NM, May 1968

Melzer Consulting

Slaughter ROZ Fairway

Roswell ROZ Fairway

Current DUROZ  
Play Area  
Yoakum County, Tx

LEA  
COUNTY,  
NM

YOAKUM  
COUNTY

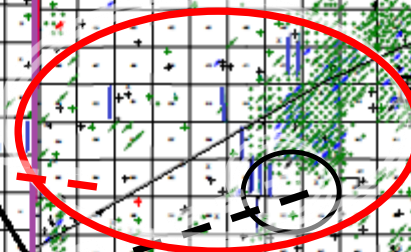
Plains

GRAHANEY  
FIELD

WASSON  
FIELD  
COMPLEX

GAINES COUNTY

Artesia ROZ Fairway

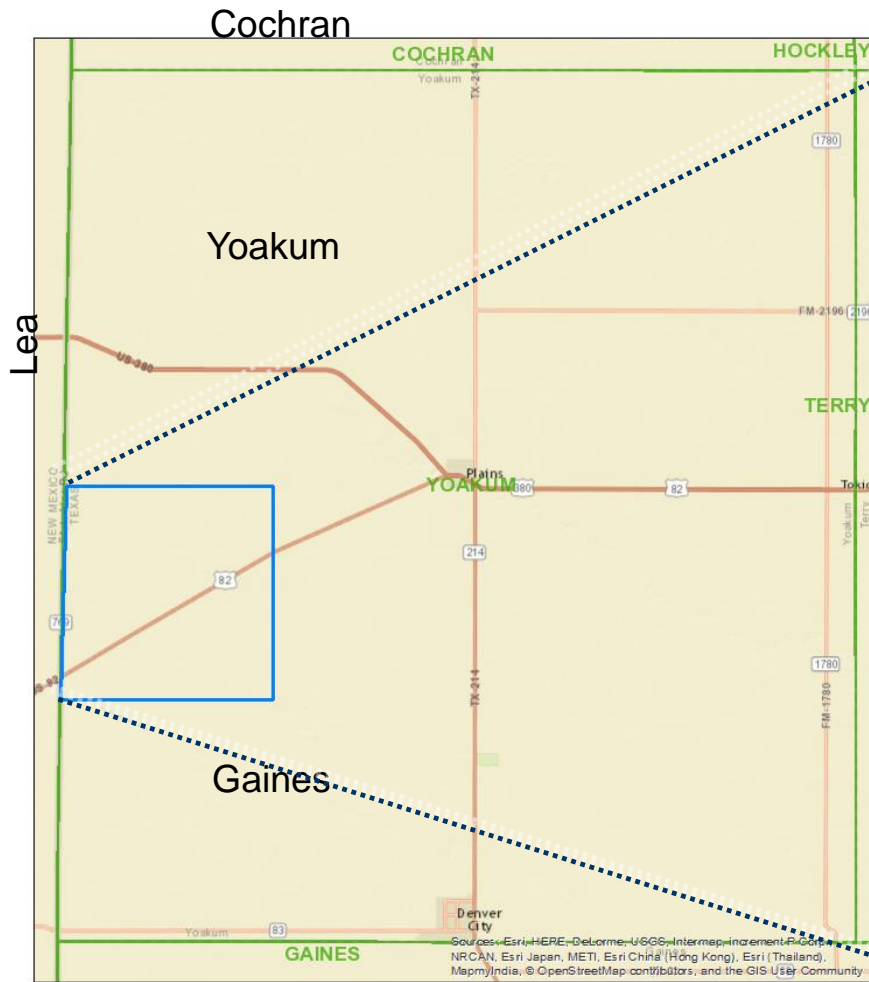


Analog (Reference Case History) Well



Melzer Consulting

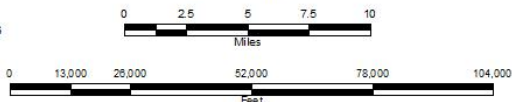
# Manzano/Walsh Area Map



November 24, 2015

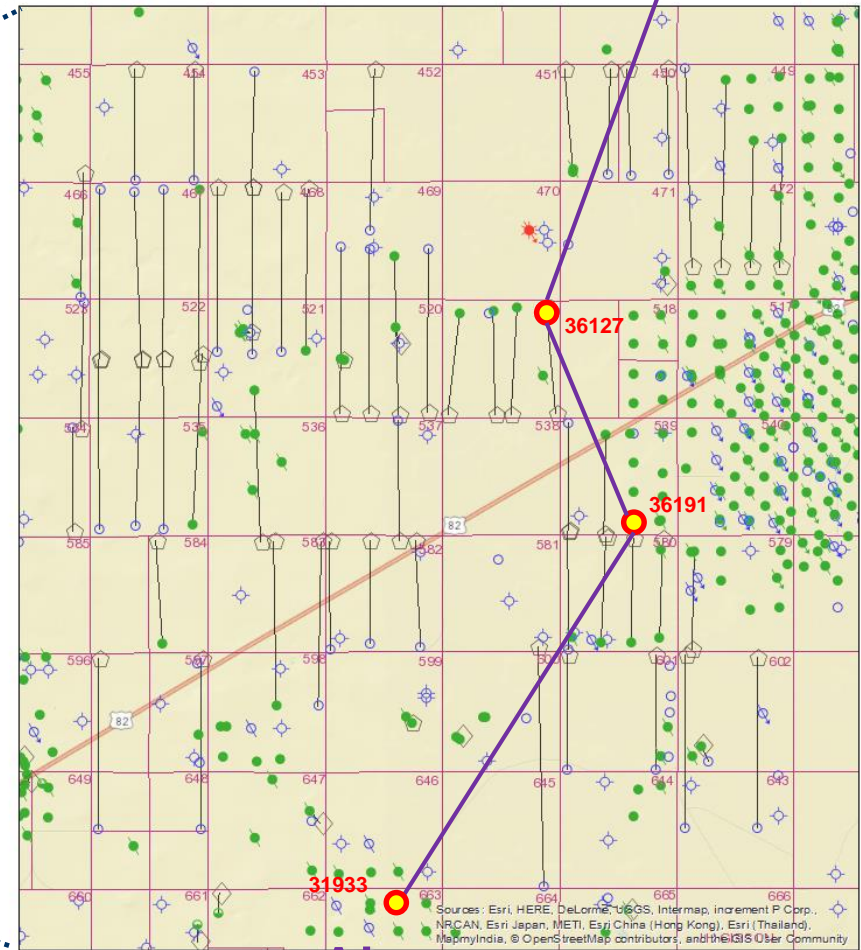
1 inch = 24,075 feet

PREPARED BY:  
RAILROAD COMMISSION of TEXAS  
P.O. BOX 12967  
AUSTIN, TX 78711-2967



NOTICE/DISCLAIMER: Mapping data sets are provided for informational purposes only. These data sets are continuously being updated and refined. Users are responsible for checking the accuracy, completeness, currency, and/or suitability of these data sets themselves. This is not a survey grade product and should not be used to define or establish survey boundaries.

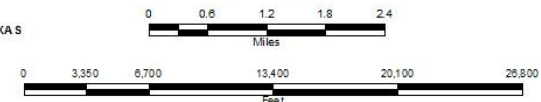
Source: RRC Public GIS Viewer



November 24, 2015

1 inch = 6,019 feet

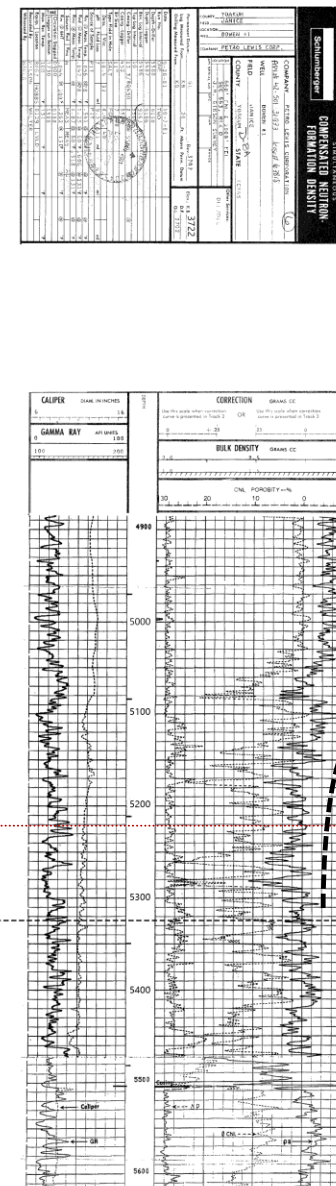
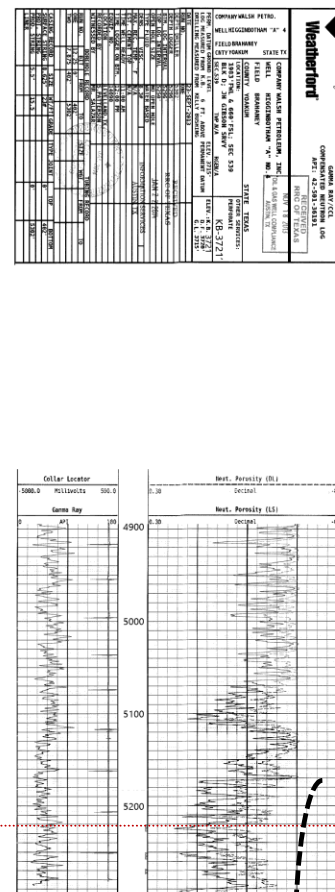
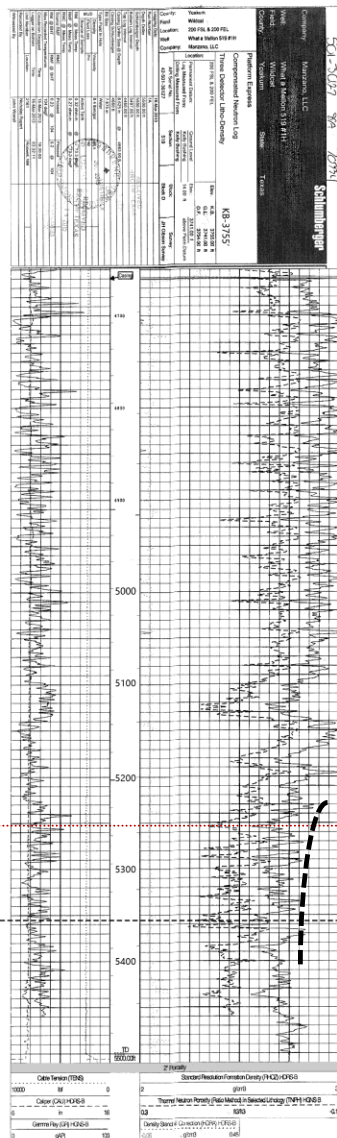
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Source: RRC Public GIS Viewer



[illegible]

A'

**-1600 msl**

-1600'

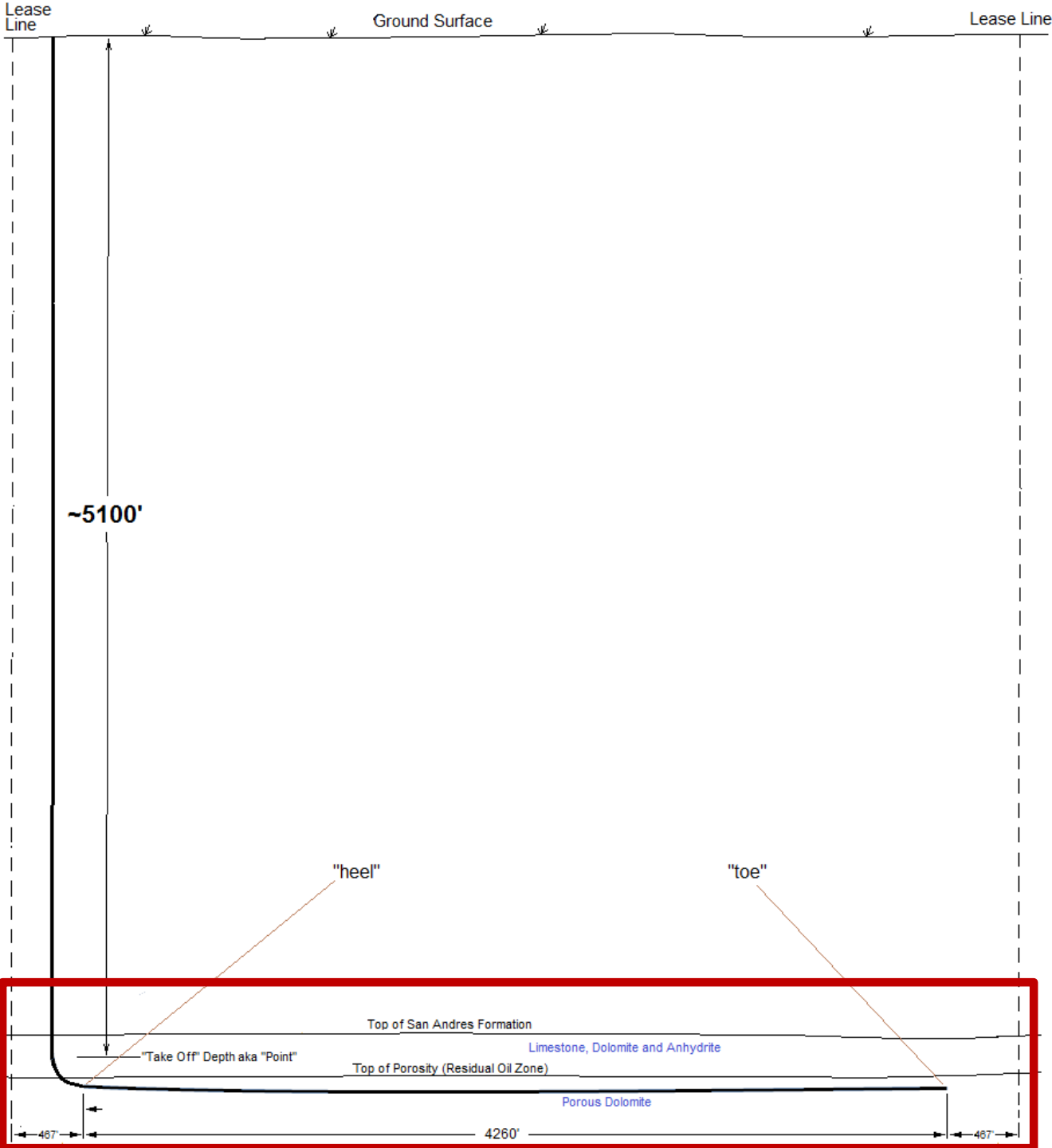
-1600'

## ***DUROZ\*: An Evolving Strategy for Producing the ROZ***

- Go to a ROZ Fairway Location, Seek and Secure a Water Disposal Option (all DUROZ ROZ wells produce water cuts in the range of 75-85%)
- Target the Good Gas/Oil Ratio ROZs
- Expose a Large Section (e.g., Long Lateral)
- Stimulate the Zone
- Pump Very Large Volumes of the Water Until Reservoir Pressures Falls Below 'Bubble Point'
- Be Patient
- Watch Oil Cuts Rise

\* Reservoir Depressuring the Upper ROZ

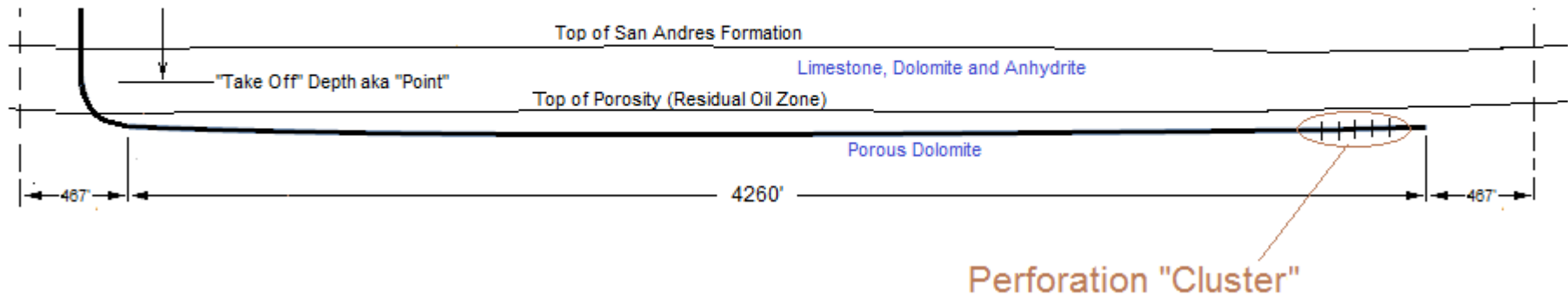
The  
DUROZ  
“Play” (as  
Currently Under  
Development as  
of Jan 2015)



# Starting the Completion

## *(First Stage Perforation)*

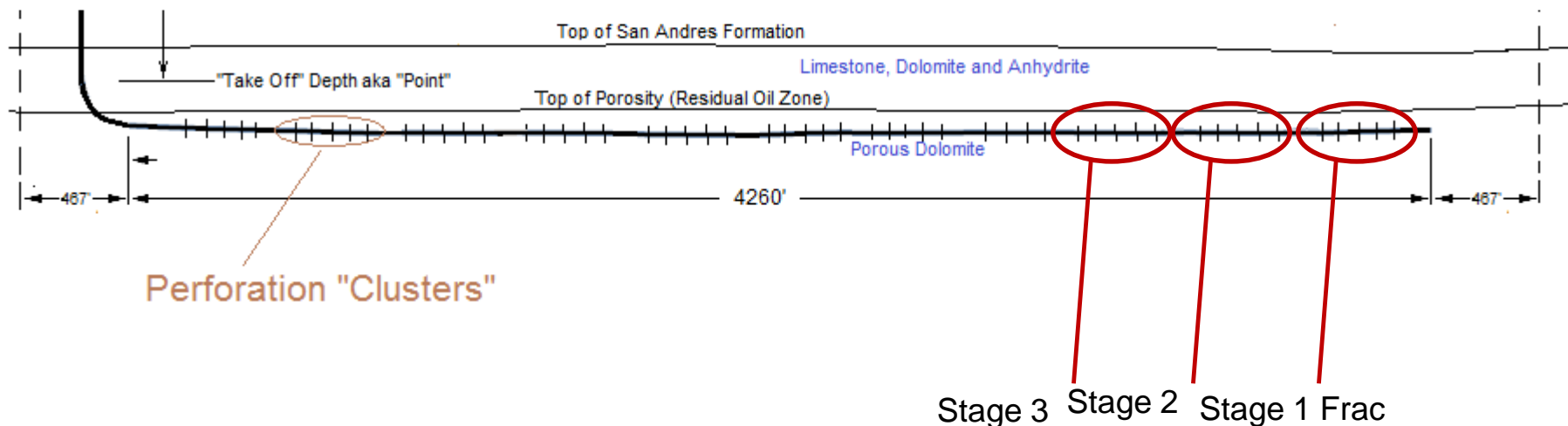
### First Stage of a Hydrofracturing Completion\*



\* Hydrofracture Technologies being used include gelled fracs, hybrid fracs and "slickwater" fracs – all successful

# Completing the Perforations (and Readied for Staged Hydraulic Fracturing)

## An Eleven Stage Hydrofracturing Completion





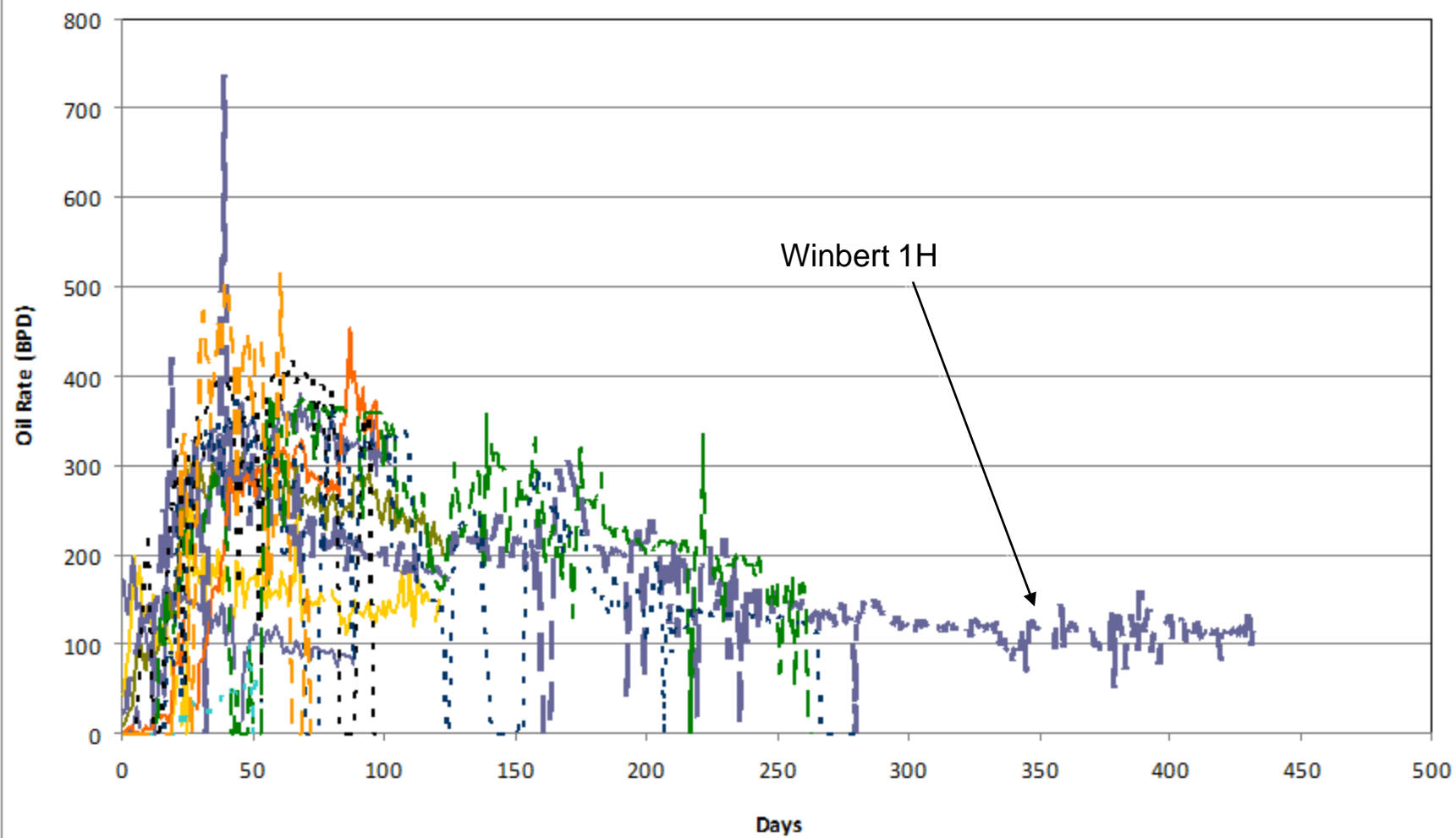
# Analog Well Performance (1)

## (DUROZ Case Histories)

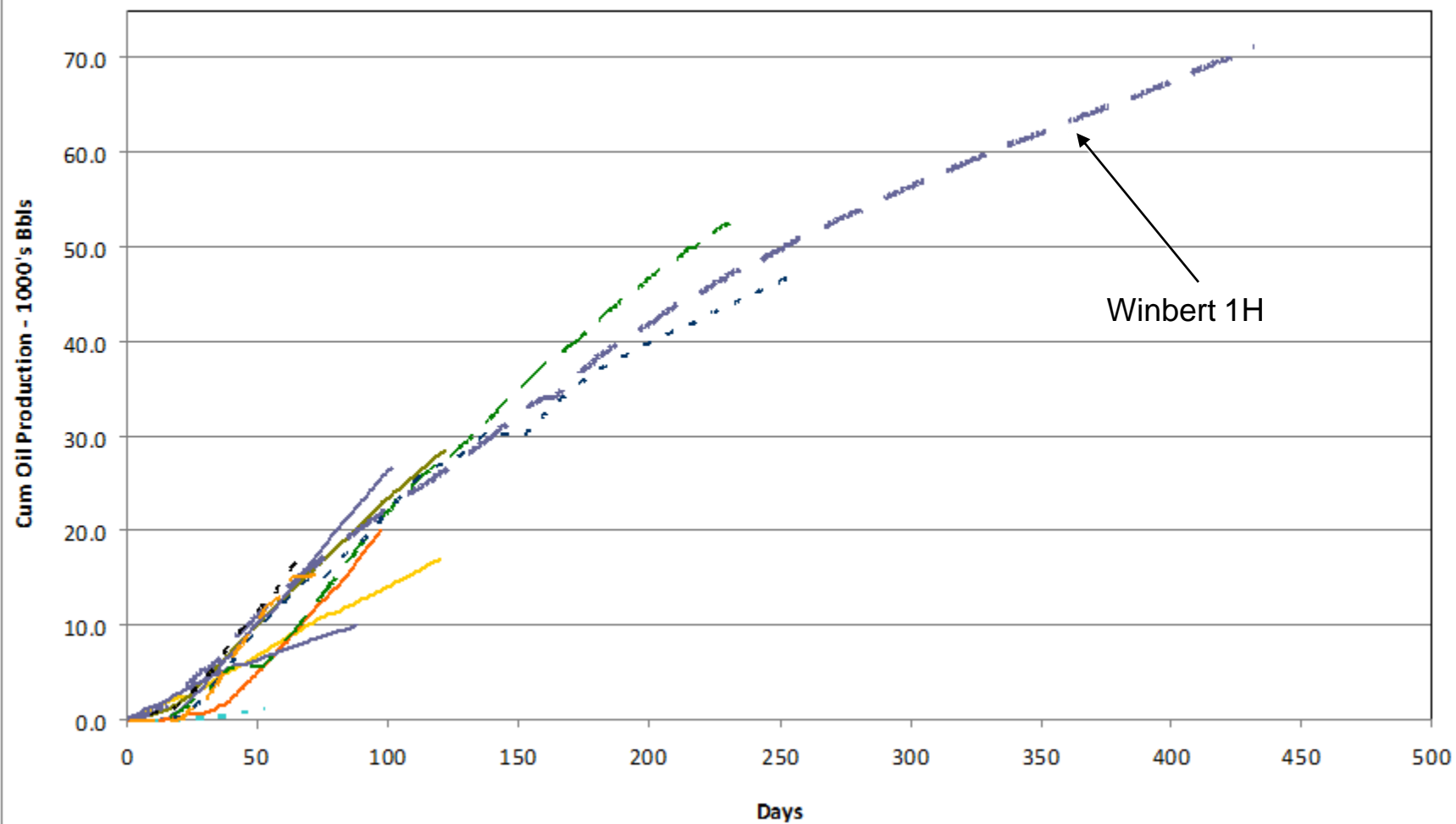
- The following data is from the older upper ROZ wells and one in particular we call our analog horizontal San Andres ROZ well in Yoakum County, Texas
- Since drilling and completing the analog well in late in 2013, 30 more DUROZ wells have been drilled and over 25 completed and, according to our conversations with the two companies involved, hydrofrac optimization is improving on the analog production case history.
- Experimentation has been occurring with 9000' laterals and recent costs of the longer lateral wells has come down to \$2.75 million where the 4500' lateral costs range from \$1.8-2.1 million



## Horizontal DUROZ Wells - Daily Production History



## Horizontal DUROZ Wells Cum Production History



# Reservoir Depressuring Stats

## DUROZ WELLS: YOAKUM CO., TX

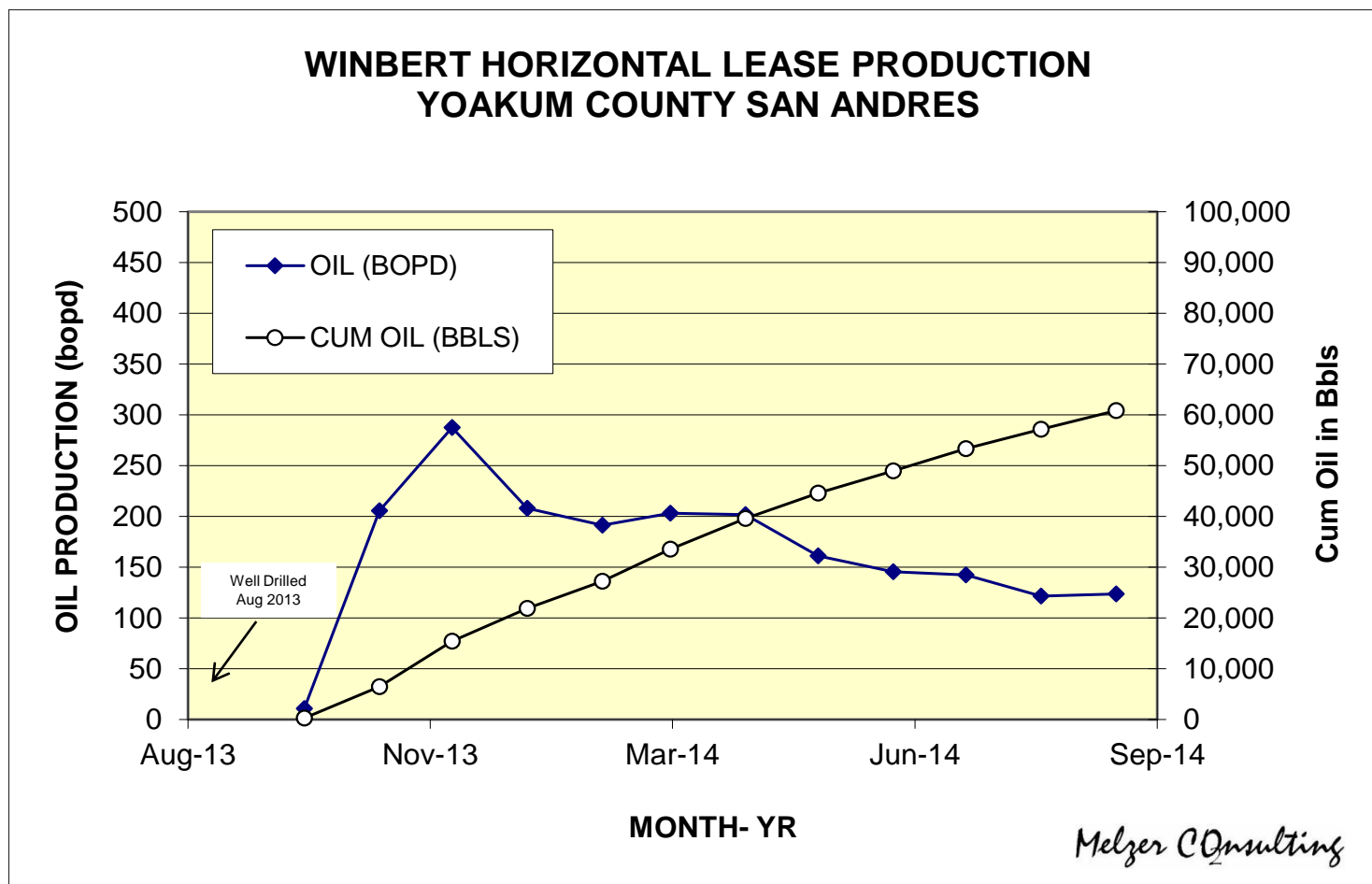
	Well	Initial Intake Pressure	First Oil Cut Intake Pressure	Lateral Length	Day	Pressure	Oil Production on 4/9/15	Days Until First Production	Cumulative Oil Production	Ave BOPD since 1st Oil
1	What A Melon 1H	1745	1225	1 mile	393	340	182	26	61,004	166.2
2	Well #2	2120	1315	1 mile	378	455	136	31	70,022	201.8
3	Well #3	1700	1270	1 mile	195	735	386	6	38,357	202.9
4	Well #4	1975	1090	1.5 mile	170	510	430	32	43,189	313.0
5	Well #5	2030	1200	1 mile	151	205	200	22	16,305	126.4
6	Well #6	2225	1150	1 mile	122	495	291	32	21,898	243.3
7	Well #7	2053	1260	1 mile	83	515	319	25	13,230	228.1
8	Well #8	2110	1635	1 mile	42	1195	79	30	1,706	142.2
9	Well #9	1820	No Oil Cut Yet	1.5 mile	20	1585	0			
10	Well #10	2040	No Oil Cut Yet	1.5 mile	20	1180	0			
11	Well #11	1750	No Oil Cut Yet	1 mile	1	1665	0			

# Analog Well Performance (2)

(Analog {1-mile} DUROZ Case History)

- A Good Average Well is also the oldest of the upper ROZ wells (Winbert 1-H), we'll call our analog horizontal San Andres ROZ well in Yoakum County, Texas
- Long Term Well Decline Analysis Complicated by the Addition of Two Wells to the Lease

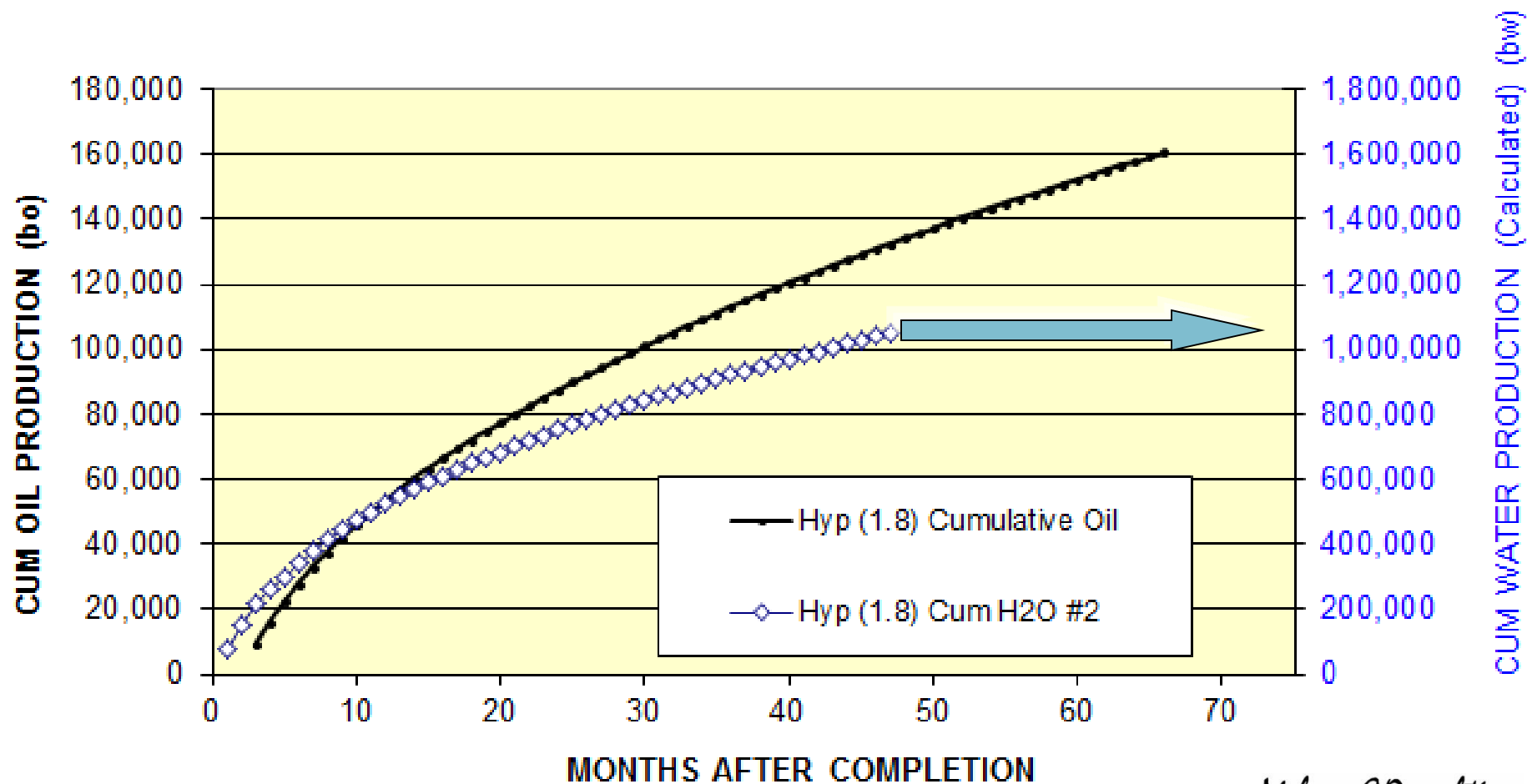
# Winbert (Brahamney Area) DUROZ Case History Yoakum County, Texas



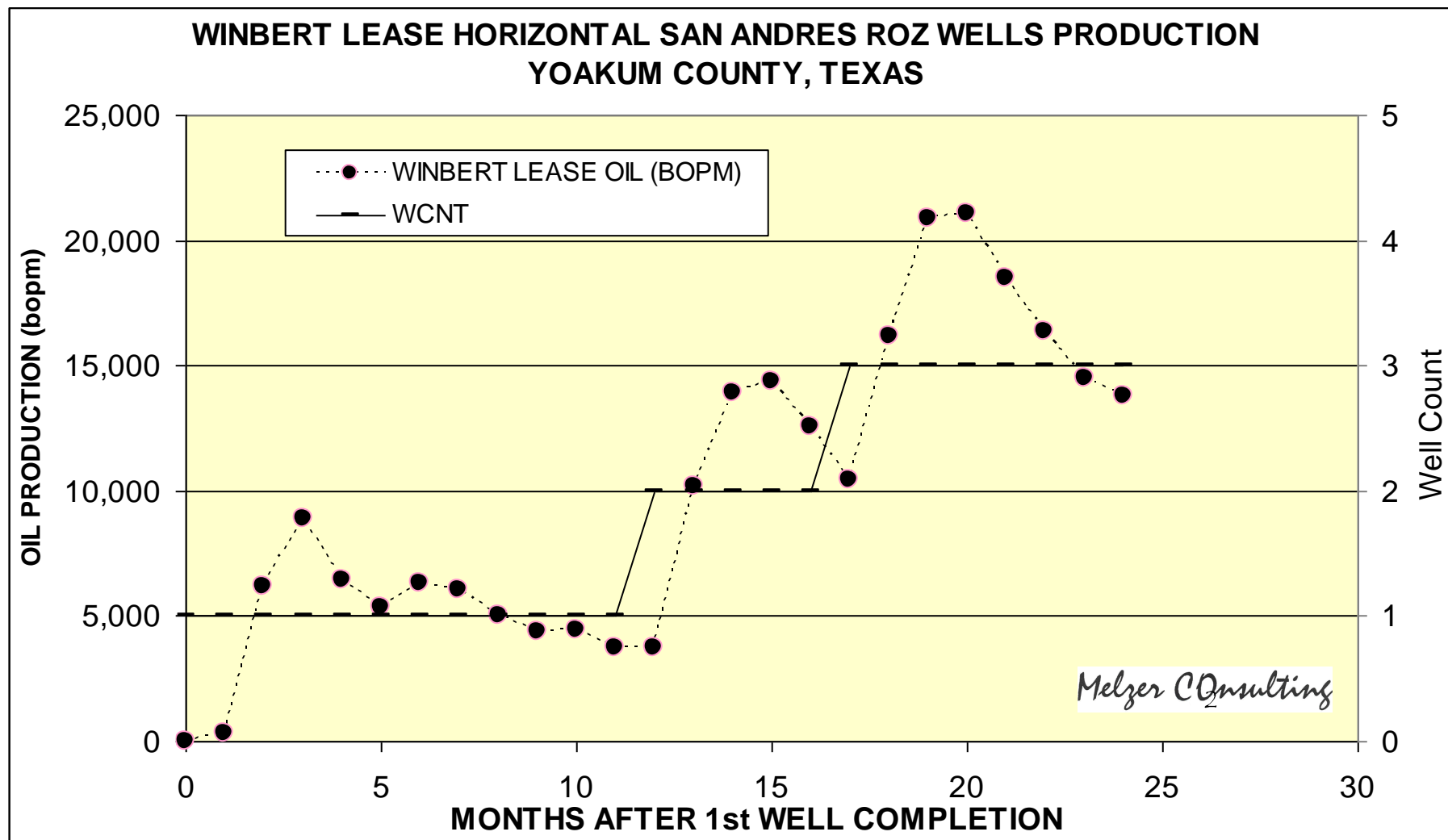
← 12 Months →

## The Produced Water Volumes are Very Large

### ANALOG HORIZONTAL SAN ANDRES ROZ WELL OIL & CALCULATED WATER PRODUCTION, NORTH SHELF, TEXAS



# Winbert Lease Update





# The DUROZ Play Summary

# DEOR/DUROZ Review {1}

- The DEOR/DUROZ Play, although very new, takes advantage of the new understanding of the widespread ROZ Fairways, high  $S_{orw}$  Values, and excellent reservoir properties of the Permian Basin San Andres porosity intervals
- The Play also takes advantage of the technological advances in horizontal drilling and completions
- The two technologies converge to make a very commercial horizontal play even at \$50/bbl oil pricing if water costs can be contained

# DEOR/DUROZ Review (Cont'd)

- The Bottom of the Prospective ROZ may not be a lithological change bringing with it hydrofracturing risks or it can be a wackestone (tight, shaley dolomite) providing an excellent containment (bottom) for the hydrofracs (~ROZ thickness of 100')
- DUROZ Zones can be stacked
- This play will have “sweetspots” like other resource plays but could be of enormous extent throughout the San Andres Shelf Regions of the PB

# DEOR/DUROZ Summary (Cont'd)

- This Area of Western Yoakum County is Laced with Dry Holes with an Occasional Shingle of Mobile Oil at the Top of the ROZ – a Classic Indicator of ROZ Greenfields
- Conventional Thought Keeps Saying that it has to be Mobile Oil that is Being Produced (Tight Oil)
- But with 30-40%  $S_{orw}$  Values in the ROZ Greenfields, there are Plenty of Reasons to Believe it is Residual Oil that is being Produced (i.e., Camp #3 – see Slide #16)

With all of this as the Premise...

What about ROZ Scalability to Other Places?

*For Both (CO<sub>2</sub>) EOR and for DEOR/DUROZ*

# Comments on Scalability to Other Areas, Other Basins in the U.S. and Abroad

- San Andres ROZ
- Other ROZs in the PB (Grayburg, Glorieta/Yeso, Clearfork, Abo)
- Hunton Dewatering Play (OK)
- Big Horn Basin (WY)
- Powder River Basin (WY)?
- Red River ROZ Play (Williston Basin)
- Others?

For more information and a complete set of slides – see 2015 CO<sub>2</sub> Conference Results on [www.CO2Conference.net](http://www.CO2Conference.net)

