The CO_2 Study Group Presents:

Projects 08123-19 & 10123-17 Permian Basin CO_2 Projects – The Future from the Past

Viola Schatzinger PTTC

Bob Trentham, CEED, UTPB

RPSEA Onshore Production Conference:Technological Keys to Unlocking Additional Reserves

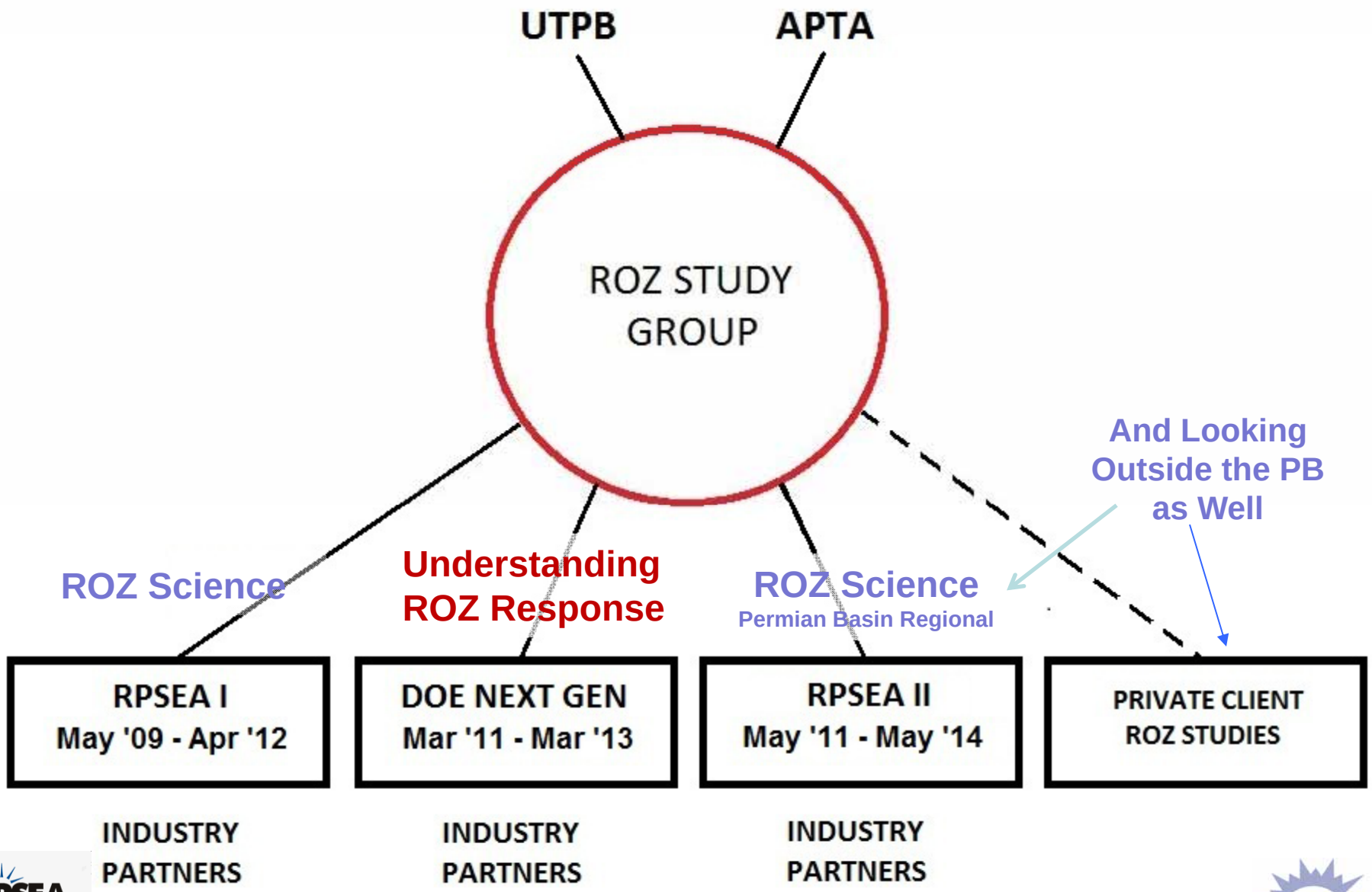
Golden, CO.

November 30, 2011

CO2 Facts

Permian Basin

- 3 Bcf of CO2 utilized per day
- 2 Bcf brought by pipeline from SW Colorado and northern New Mexico
  - McElmo Dome, Doe Canyon, Sheep Mountain and Bravo Dome
- Sequester around .5 Bcf of CO2 per day
- Make 200, 000 barrels of oil per day using CO2
- Currently 10,000 BOPD from ROZ CO2 floods
- Cumulative oil from CO2 is over 1 billion barrels
- Two FutureGen style plants being built
  - Pennwell – will capture 140 MMcf CO2/day
  - Tensaka builing a post combustion plant at Sweetwater
  - Both will sell CO2 for EOR projects.


UTPB
APTA
ROZ STUDY GROUP
And Looking Outside the PB as Well
ROZ Science
Understanding ROZ Response
ROZ Science
Permian Basin Regional
RPSEA I
May '09 - Apr '12
DOE NEXT GEN
Mar '11 - Mar '13
RPSEA II
May '11 - May '14
PRIVATE CLIENT ROZ STUDIES
INDUSTRY PARTNERS
INDUSTRY PARTNERS
INDUSTRY PARTNERS

UTPB – APTA Projects

- DOE_Research Partnership to Secure Energy (RPSEA): Improved Oil Recovery for Small Producers, **"Commercial Exploitation and the Origin of Residual Oil Zones: Developing a Case History in the Permian Basin of New Mexico and West Texas".** Co-PI's: Robert C. Trentham, Steve Melzer, **2 1/2 years, $ 631,001, Plus $110,000 from industry partners**, End date March 9, 2012
- DOE: Recovery Act: Regional Sequestration Technology Training, **"Carbon Capture and Storage in the Permian Basin, A Regional Technology Transfer and Training Program." Co PI's: PTTC, AAPG, APTA, Total Funding Requested: $ 994,998, UTPB/CEED as Subcontractor: $84,270, July 22, 2009**.
- DOE Recovery Act: "**A Modular Curriculum for Training University Students in Industry Standard CO2 Sequestration and Enhanced Oil Recovery Methodologies", Co-PI's: Dr Emily Stoudt, Dr Robert Trentham, DOE $ 296,000, Start Date Aug 11, 2009**.
- National Energy Technology Lab (NETL): **"Using Next Generation CO2 EOR Technologies to Optimize the Residual Oil Zone CO2 Flood at Goldsmith Landreth Unit, Ector County, Texas"**, PI: Robert Trentham, Start 2/23/2011-9/30/2013. NETL $1,198,547.00 Industry Match $654,563.00
- RPSEA: **"Identifying and Developing Technologies for Enabling Small Producers to Pursue the Residual Oil Zones (ROZ) Fairways in the Permian Basin, San Andres"** Co-PI's Robert C. Trentham, Steve Melzer, Start 5/01/2011, end 11/01/2013, $1,243, 369.98, RPSEA Share, $859,269.98 Industry Match: $374,100.00

The World of Residual Oil Zones

Focus Today: San Andres ROZs
in the Permian Basin

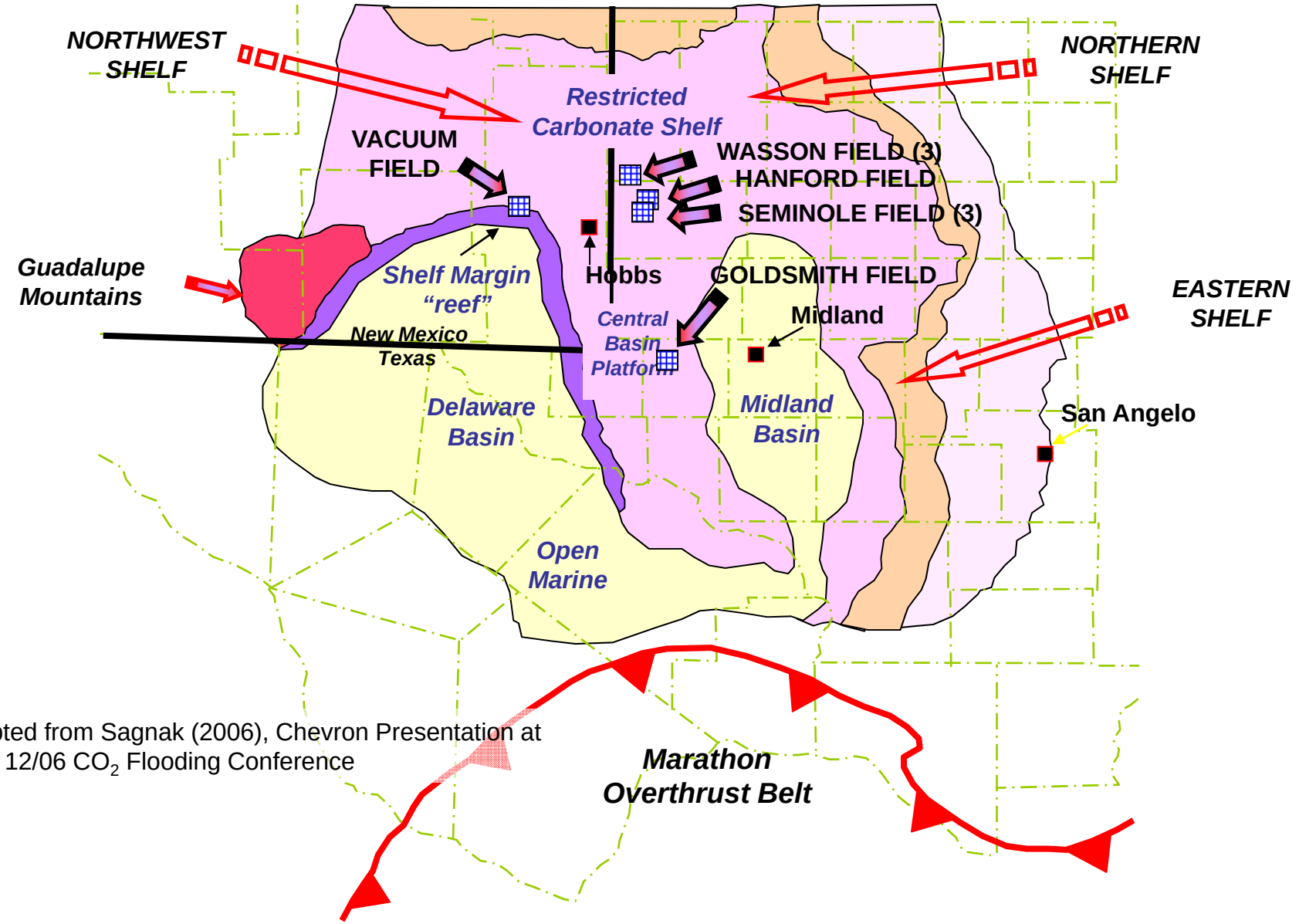
Residual Oil Zone

ROZ

- Zone of immobile oil left after the oil has migrated out of the original geologic reservoir.
- Concept based on discovery in the Permian Basin that below the oil/water contact an unexpected oil reservoir existed.
- ROZ characteristics similar to a mature waterflooded reservoir.
- Lateral flushing occurred geologically sometime after original emplacement.
- Mother Nature's Waterflood
- CO2 EOR target- ROZ have been waterflooded by Mother Nature

MIDDLE SAN ANDRES PALEOGEOGRAPHY

with Location of Industry Documented ROZ Zones/Fields*



* Adapted from Sagnak (2006), Chevron Presentation at the 12/06 CO_2 Flooding Conference

The List of On-going ROZ Projects

Type and operator	Field	State	County	Top MPZ Depth, ft	Pay zone
Active CO_2 miscible					
Chevron	Vacuum San Andres Grayburg Unit	NM	Lea Co.	4,550	San Andres/Grayburg
Fasken	Hanford	Tex.	Gaines	5,500	San Andres
Hess	Seminole Unit-ROZ Phase 1	Tex.	Gaines	5,500	San Andres
Hess	Seminole Unit-ROZ Phase 2	Tex.	Gaines	5,500	San Andres
Hess	Seminole Unit-ROZ Stage 1 Full Field Dev	Tex.	Gaines	5,500	San Andres
Legado	Goldsmith-Landreth Unit	Tex.	Ector	4,200	San Andres
Occidental	Wasson Bennett Ranch Unit	Tex.	Yoakum	5,250	San Andres
Occidental	Wasson Denver Unit	Tex.	Yoakum	5,200	San Andres
Occidental	Wasson ODC	Tex.	& Gaines	5,200	San Andres

Announced Additions: Exxon at Means (2011)

Rumored Additions: Conoco at East Vacuum (2011)
Chevron at Central Vacuum (2012)
XTO at CA Goldsmith (2013?)
Tabula Rasa at E. Seminole and Lindoss (2013)

Where we are today

- ROZ's appear to be common in Leonardian and Guadalupian carbonates on the Central Basin Platform and Northwest Shelf.
- Exploitation of thick ROZ's associated with many of the major San Andres fields has begun with CO2 projects underway at Wasson, Seminole, Vacuum, Means, Goldsmith, and Hanford Fields, with others planned.
- Production from ROZ's and anecdotal evidence from exploration wells, coupled with the theory/model of the development of Residual Oil Zones (ROZ's), has led to the belief that there are potentially billions of barrels of additional producible tertiary reserves in the Permian Basin and elsewhere.

Calibrating the Oil Recovery Models and EstimatingTechnically Recoverable ROZ Oil – MPZ and TZ/ROZ Oil in Place

56 fields in five major Permian Basin oil plays that have potential for significant TZ/ROZ resources were identified by ARI.

TZ/ROZ OOIP in these 56 fields is estimated to be 30.7 Billion Barrels.

Field/Unit	MPZ OOIP (BB)	TZ/ROZ OOIP (BB)	No. of Fields	No. of MPZ Fields with CO2-EOR Projects	No. of Fields with TZ/ROZ CO_2-EOR Projects
1. Northern Shelf Permian Basin (San Andres)	13.0	13.2	13	5	1
2. North Central Basin Platform (San Andres/Grayburg)	2.9	2.6	6	2	1
3. South Central Basin Platform (San Andres/Grayburg)	9.9	7.9	16	5	0
4. Horseshoe Atoll (Canyon)	5.4	2.9	10	4	2
5. East New Mexico (San Andres)	2.3	4.1	11	2	0
Total	33.5	30.7	56	18	4

Technically Recoverable Resources from the MPZ and ROZ

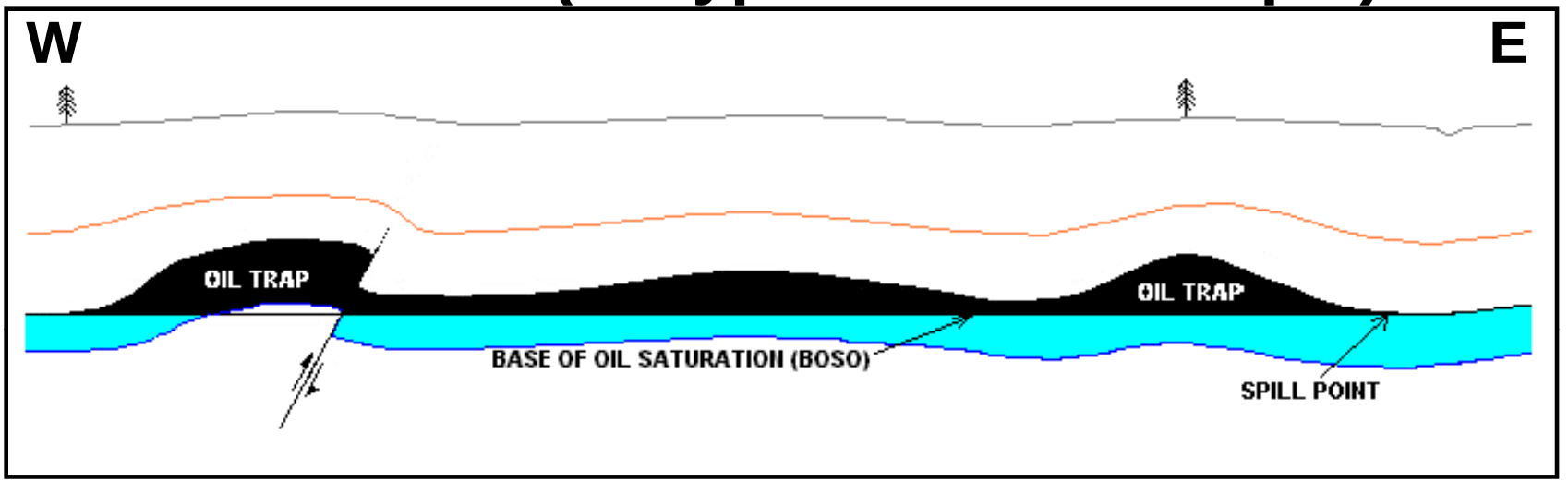
Based on reservoir modeling of applying CO_2-EOR to the TZ/ROZ resources, ARI estimates that

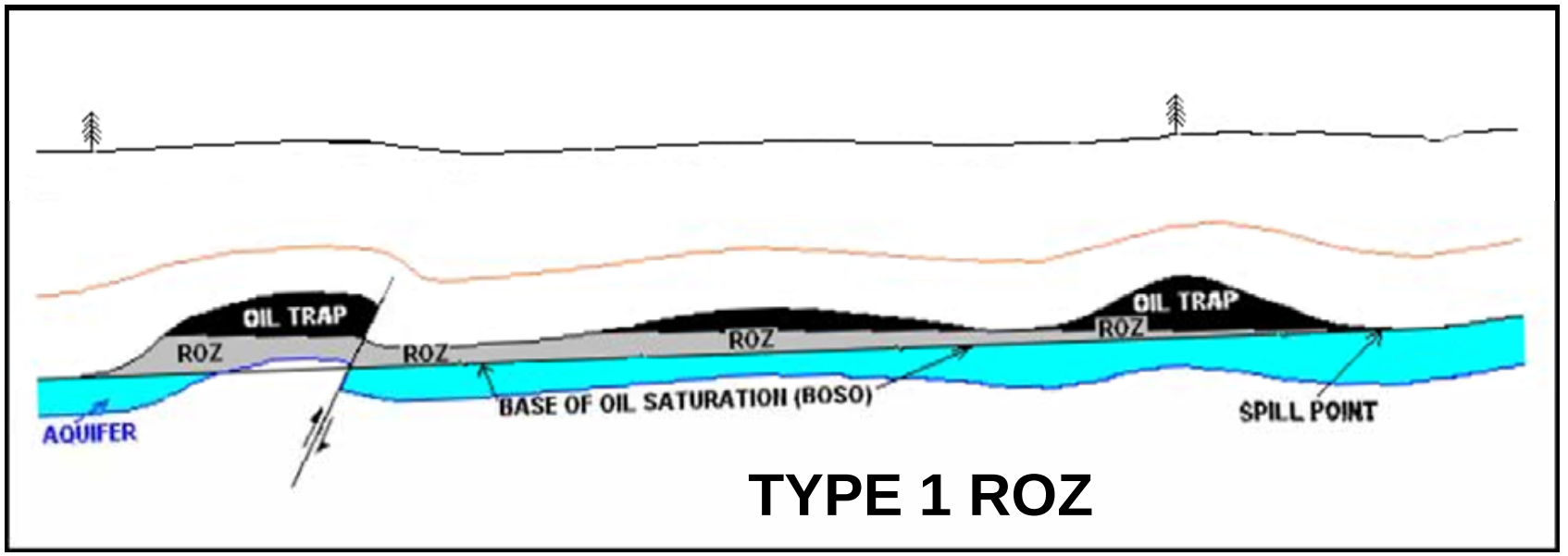
11.9 Billion BO is technically recoverable from the 30.7 Billion BO of TZ/ROZ oil in-place in these five Permian Basin oil plays

Field/Unit	Total CO_2-EOR (BB)	MPZ CO_2-EOR (BB)	TZ/ROZ CO_2-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

The Science of Residual Oil Zones

Original Oil Accumulation Under Static Aquifer Conditions (A Hypothetical Example)

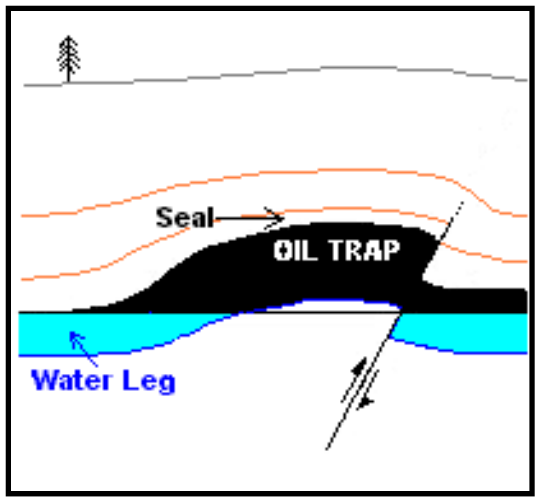




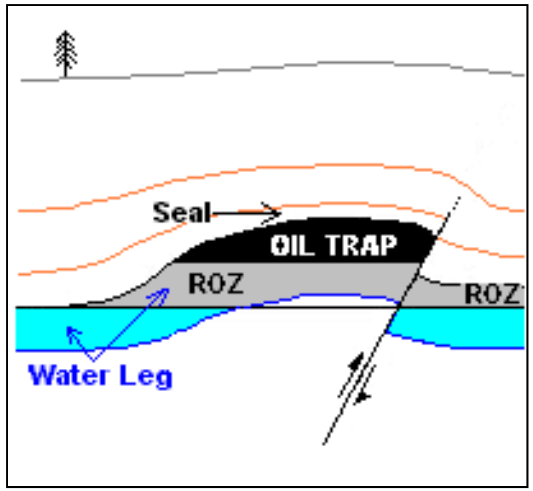
TYPE 1 ROZ

Original Accumulation with a Breached then Repaired Seal & Forming a ROZ

ORIGINAL

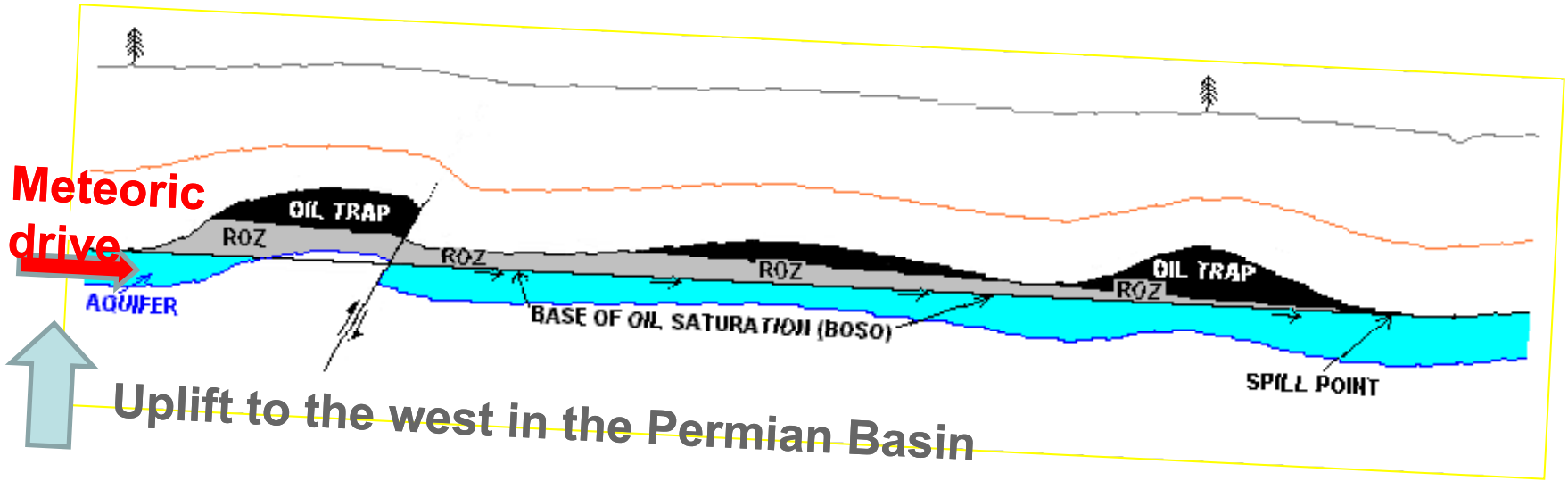


POST BREACH

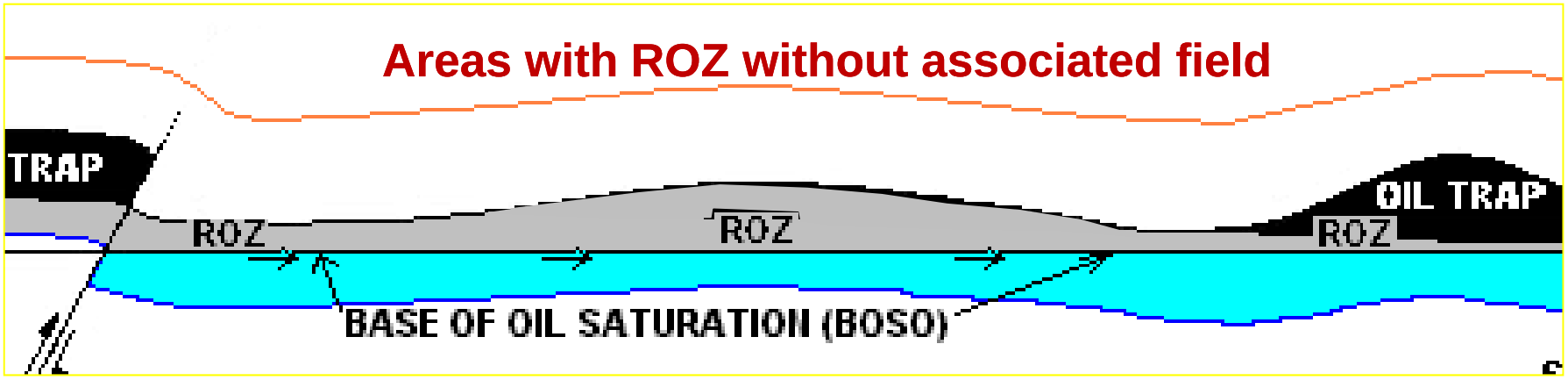


TYPE 2 ROZ

TYPE 3. Change in Hydrodynamic Conditions, Sweep of the lower part of the Oil Column and Development of a Residual Oil Zone.

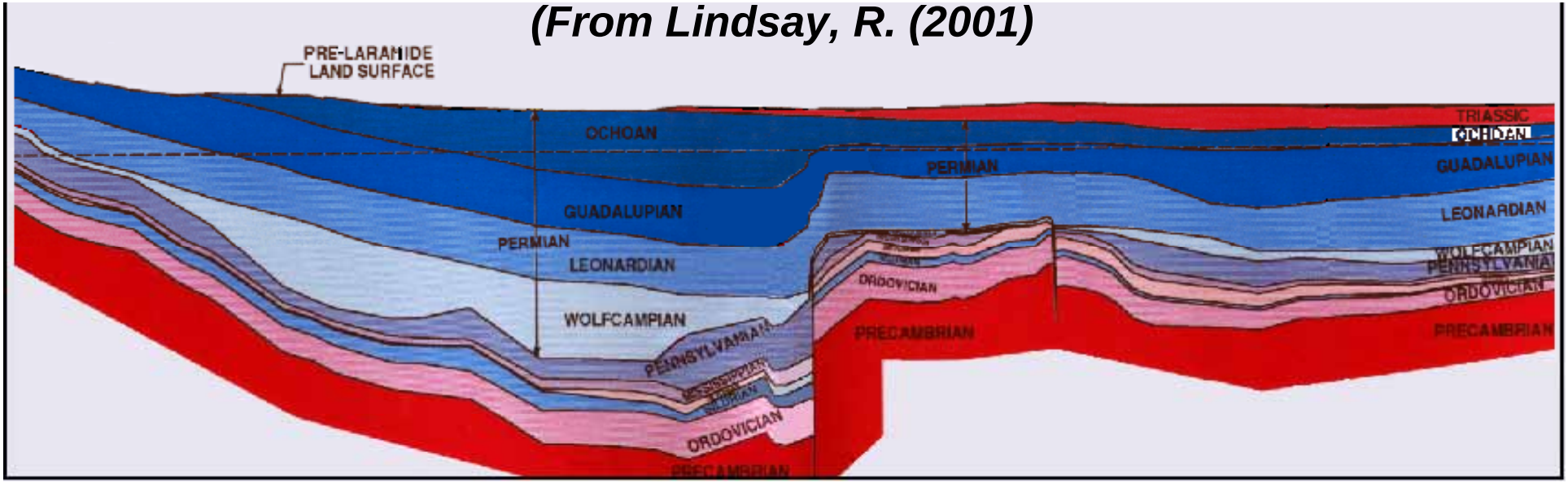


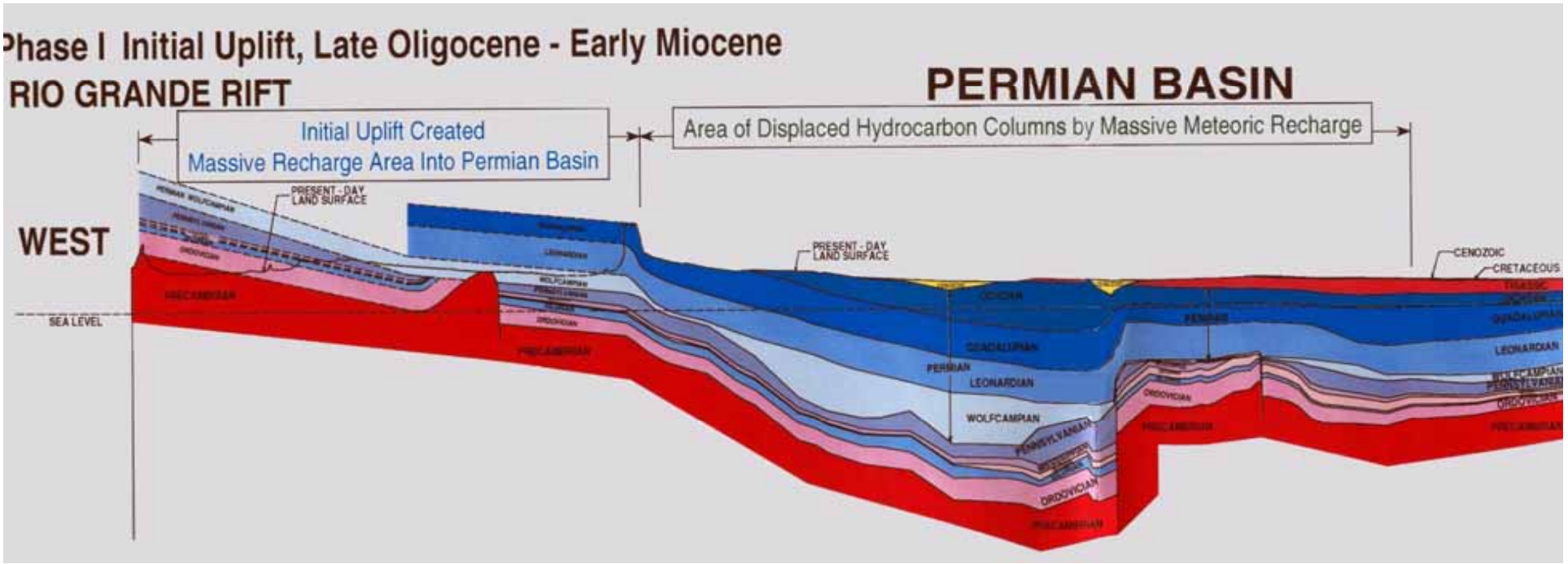
Dynamic System



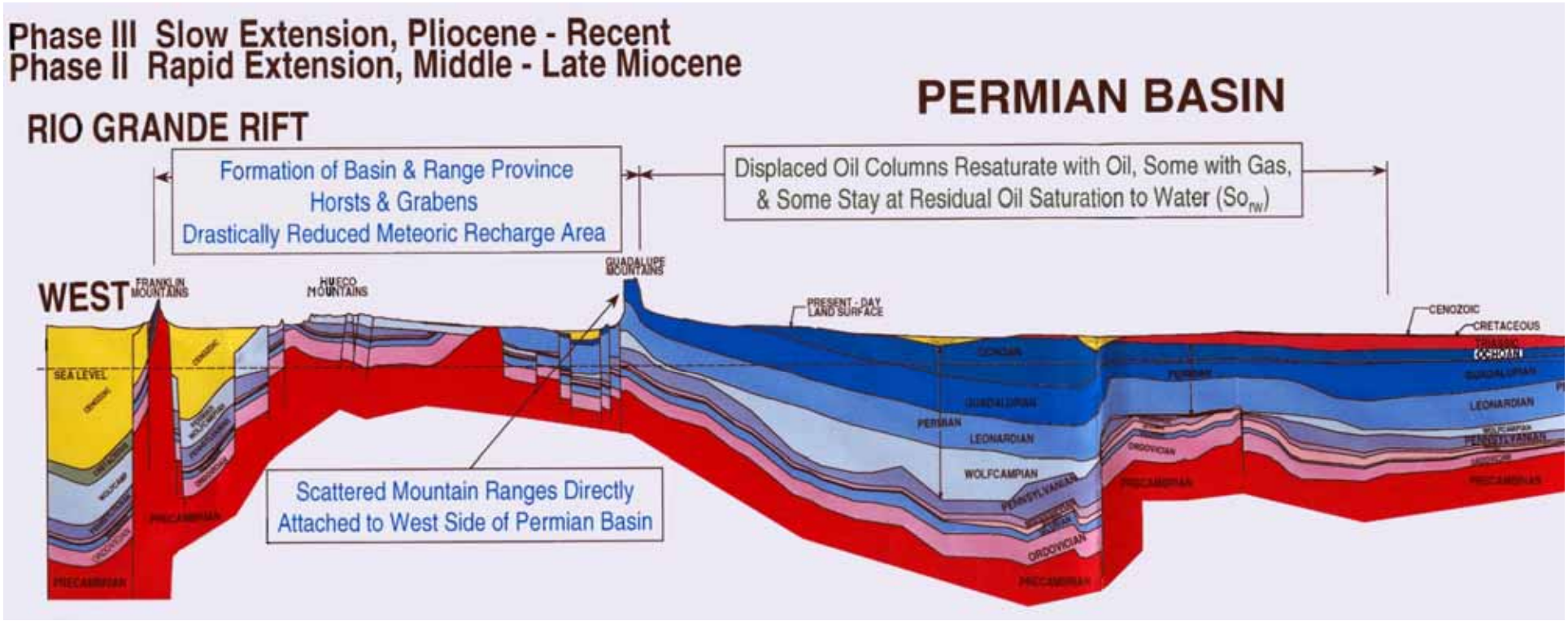
Post-Subsidence Phase of Permian Basin Development

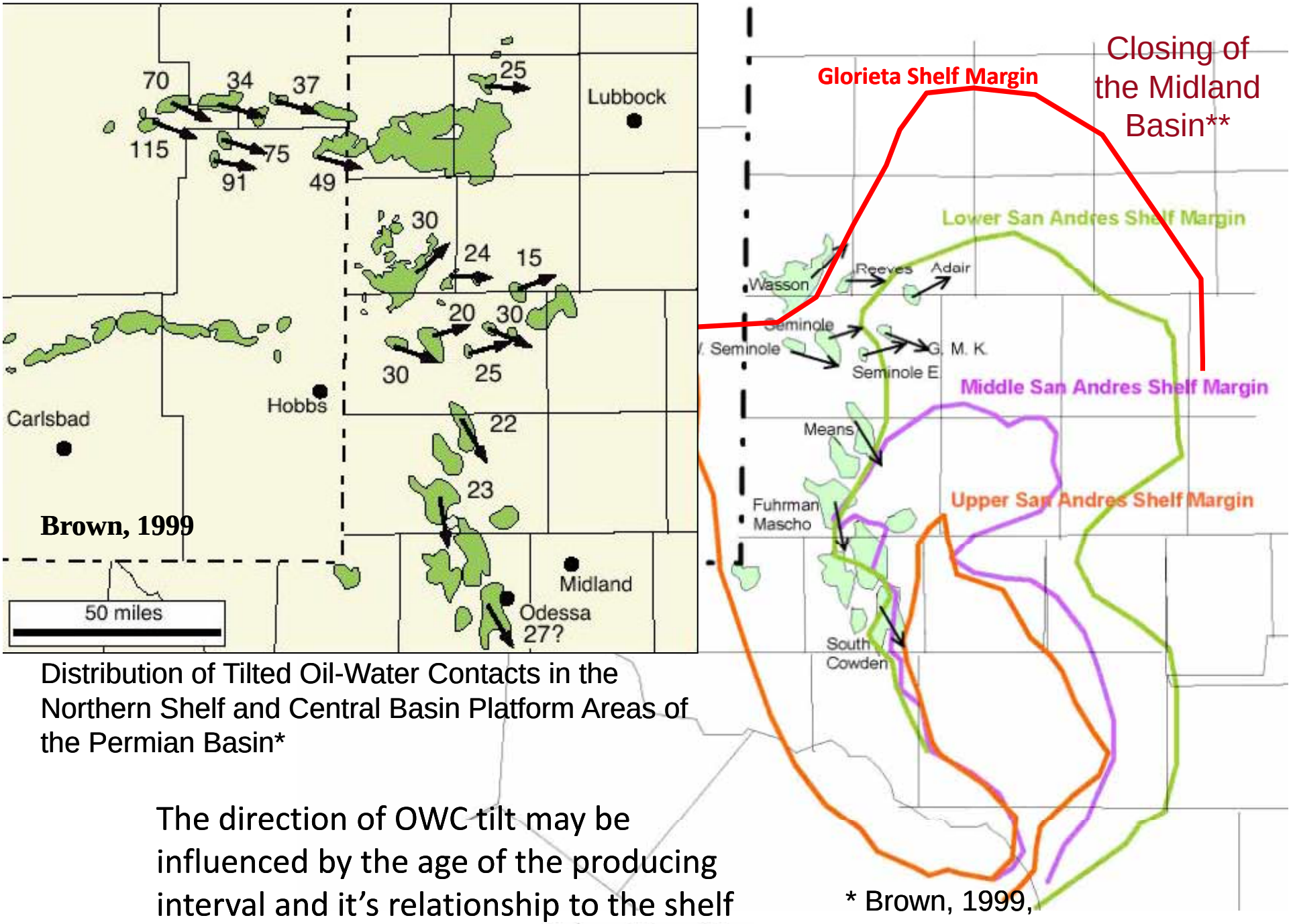
(From Lindsay, R. (2001)





Extensional Phases and Reduction of Hydrodynamic Gradients in the Permian Basin *(From Lindsay, R. (2001)*



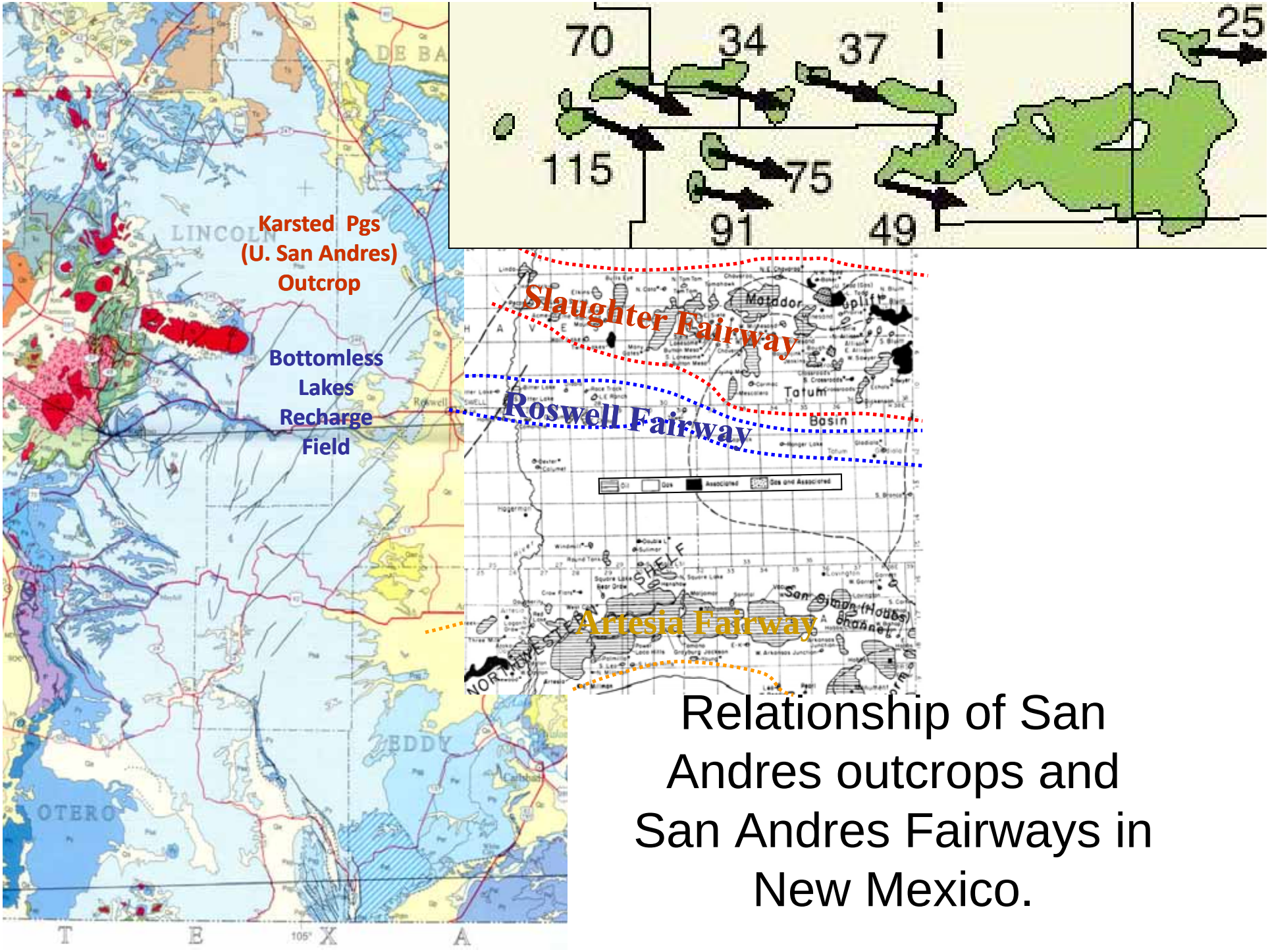


Distribution of Tilted Oil-Water Contacts in the Northern Shelf and Central Basin Platform Areas of the Permian Basin*

The direction of OWC tilt may be influenced by the age of the producing interval and it's relationship to the shelf margin

Melzer Consulting

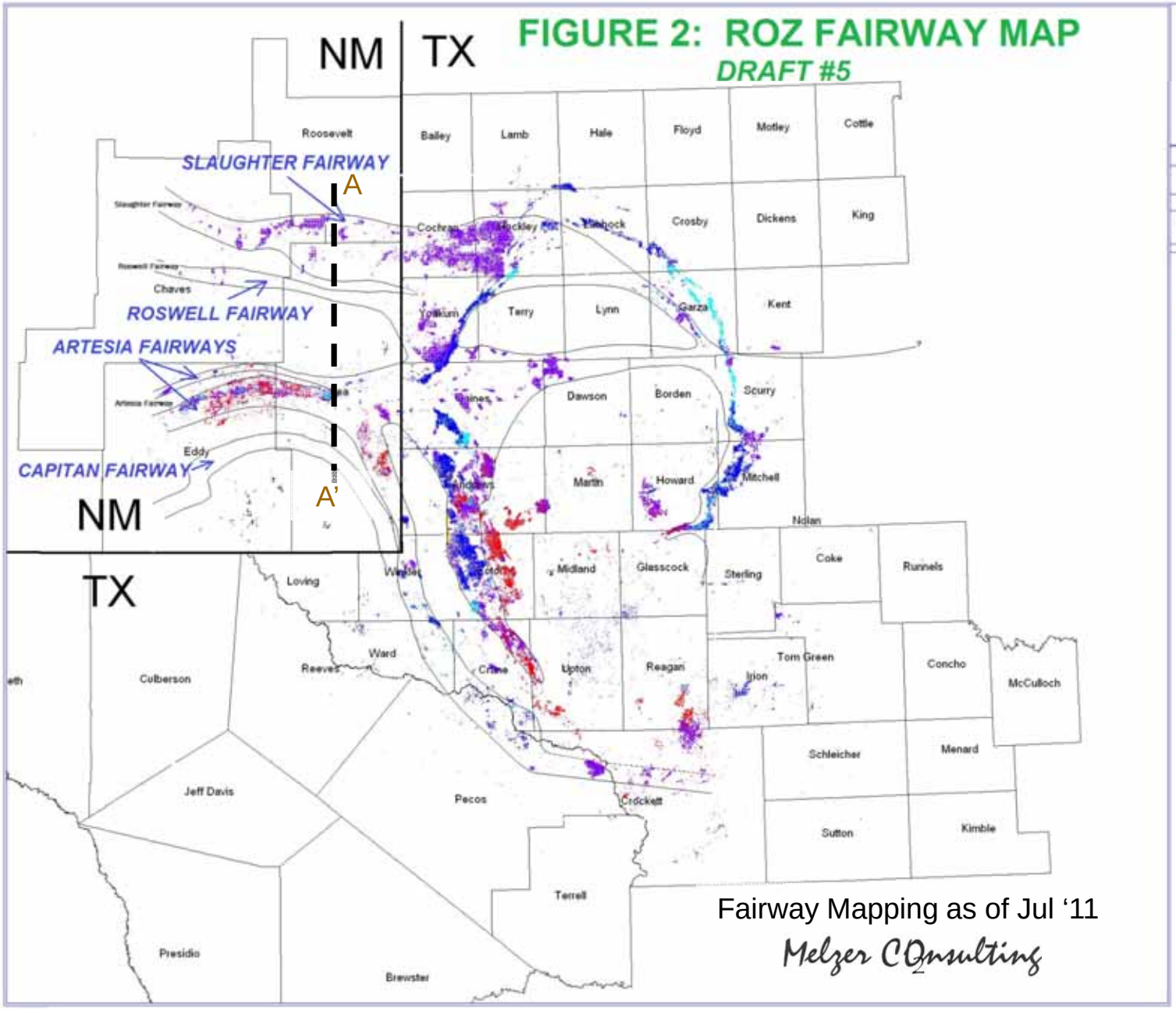
* Brown, 1999,
** Ward et al, 1986



Relationship of San Andres outcrops and San Andres Fairways in New Mexico.

FIGURE 2: ROZ FAIRWAY MAP

DRAFT #5



Fairway Mapping as of Jul '11

Melzer CO2nsulting

Melzer COnsulting

Permian Basin

RPSEA

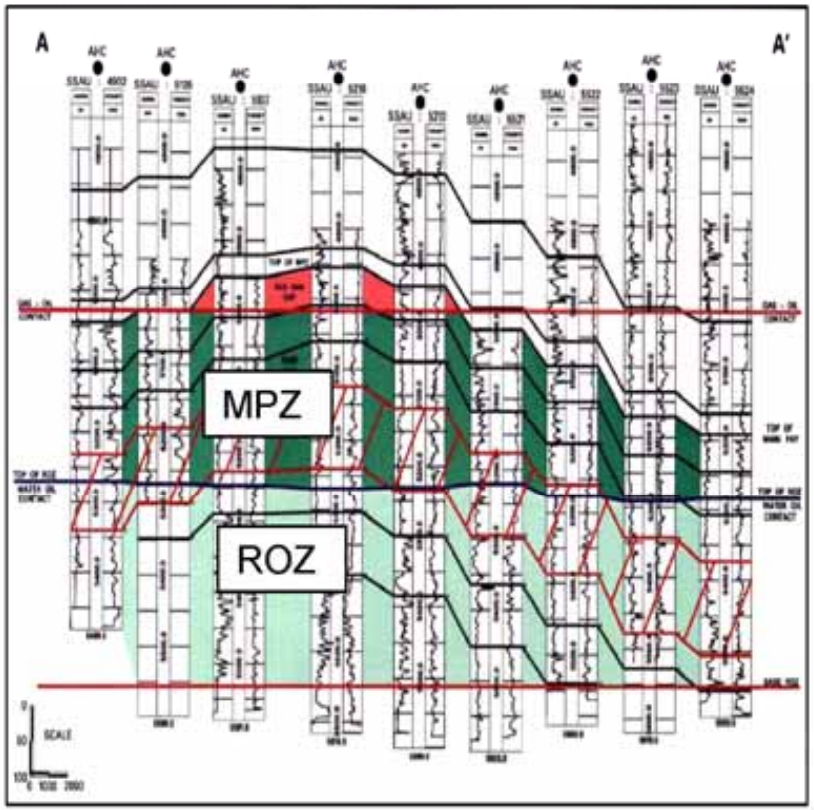
Research Partnership to Secure Energy for America

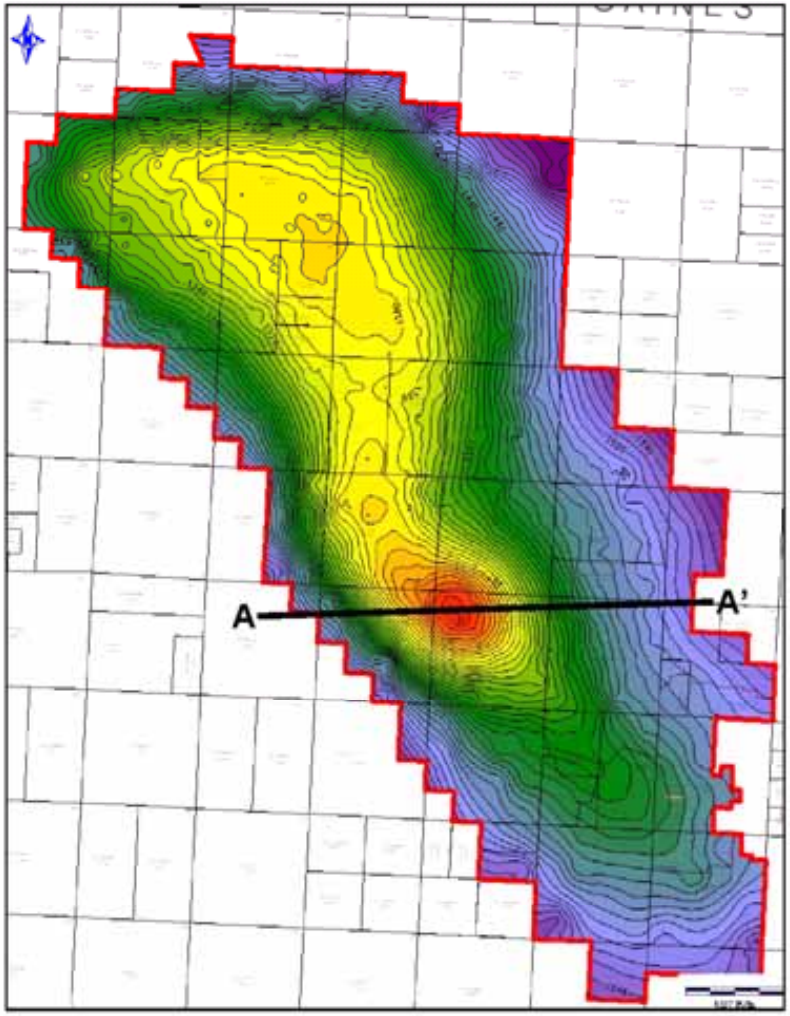
The Gold Standard

Seminole San Andres Unit

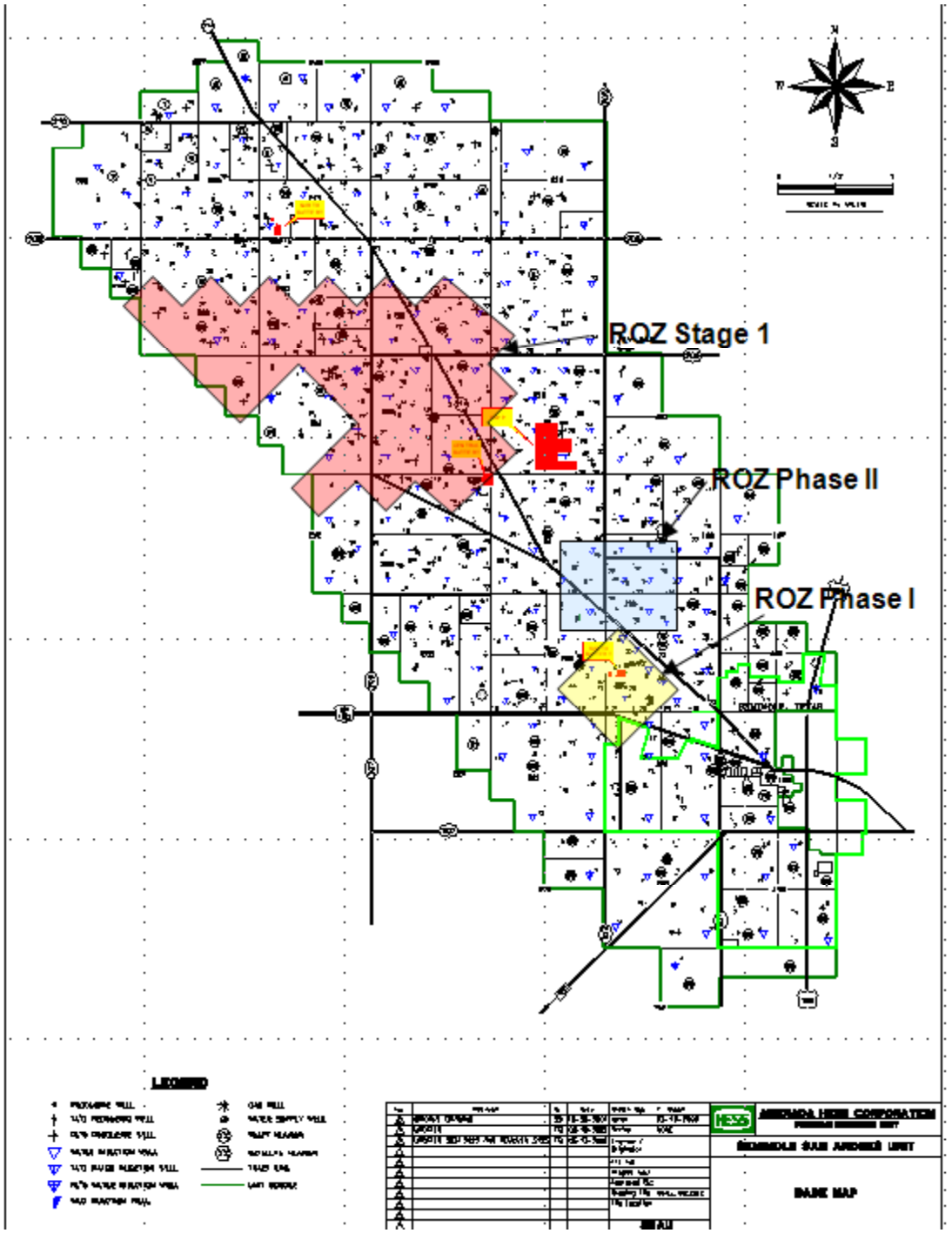
SSAU Structure Map & Cross Section

	Net Thickness	Average Permeability	Initial Oil Saturation
Main Pay Zone (MPZ):	126'	9 md	84%
Residual Oil Zone (ROZ):	213'	12 md	32%

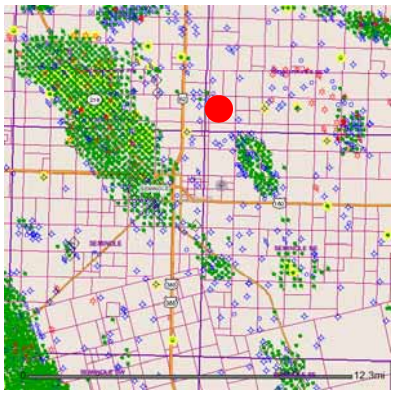




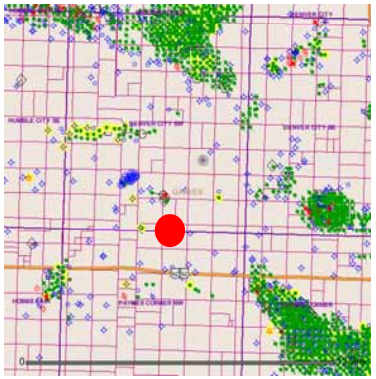
Seminole Field ROZ Projects



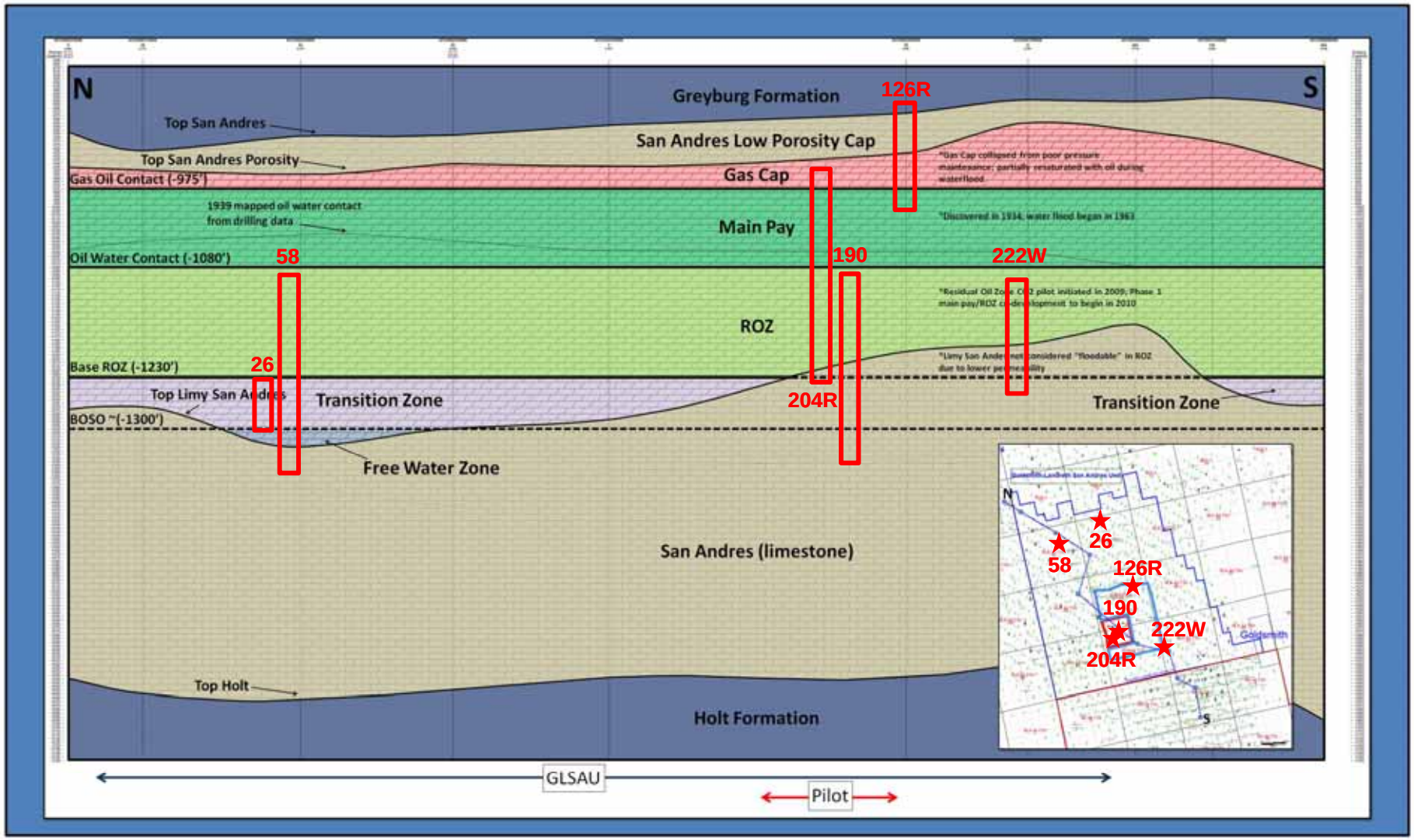
Gaines, Future Targets or goat pasture?



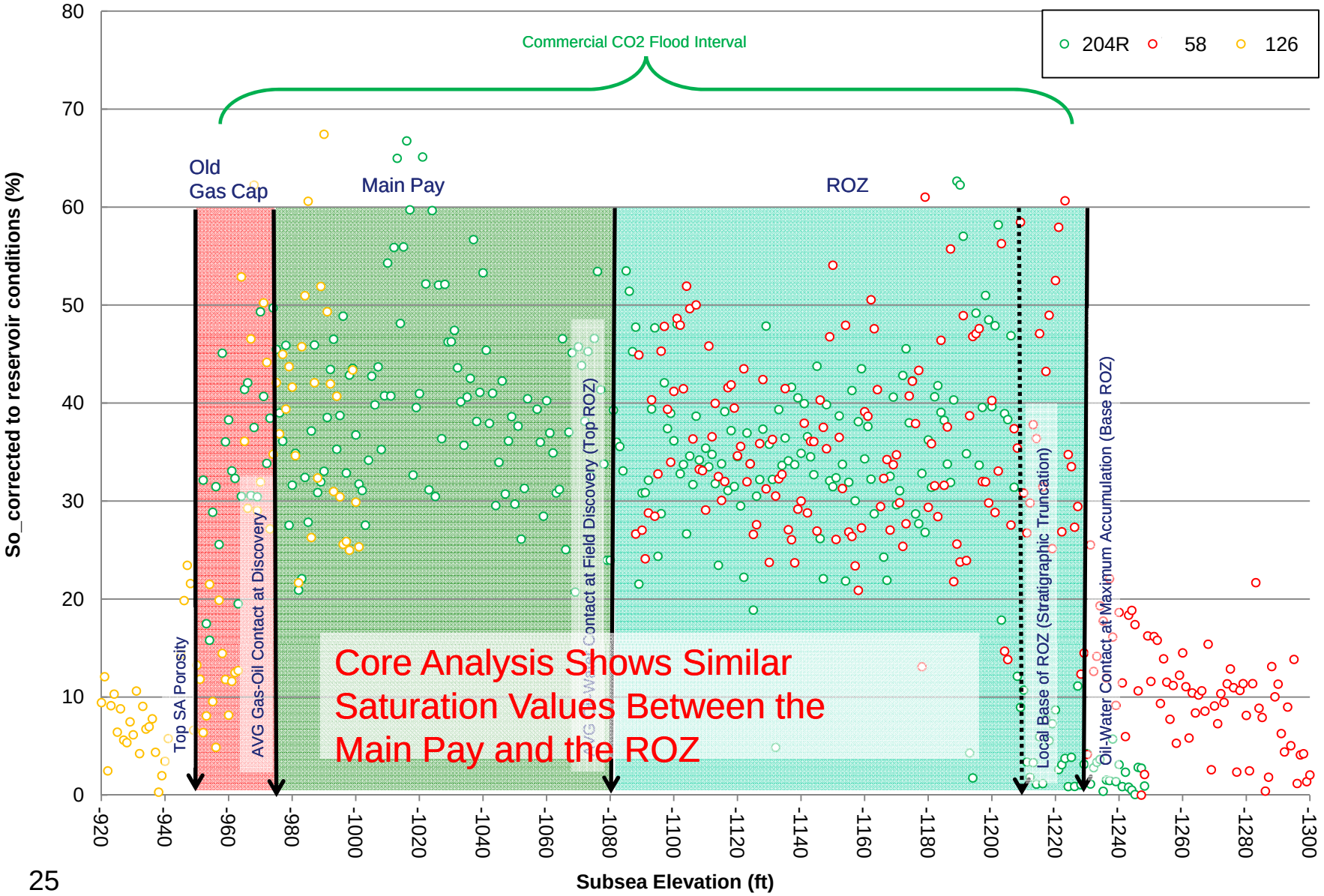
- A Clearfork test, the **IP #1 Campbell Heirs "158**" set pipe on "WET" San Andres test just south of Seminole.
- All wireline logs, drill time, gas curves and sampleshows said "slam dunk" oil production. Atlas log analyst said it should be a producer. 100% water test with barely a sniff of live oil. ROZ?
- **Anschutz #1 Patrick Keating** "447", drilled for San Andres west of Seminole, had good shows but made only water for a few months before P & A (3600 BW, 3 BO). Water analyses show progressive drop in TDS over the two months of production.
- The 2 CORED intervals, from 5464 – 5602, had oil saturations ranging from 15 to 35%, 3 - 12% porosity, & 50-100% fluorescence.



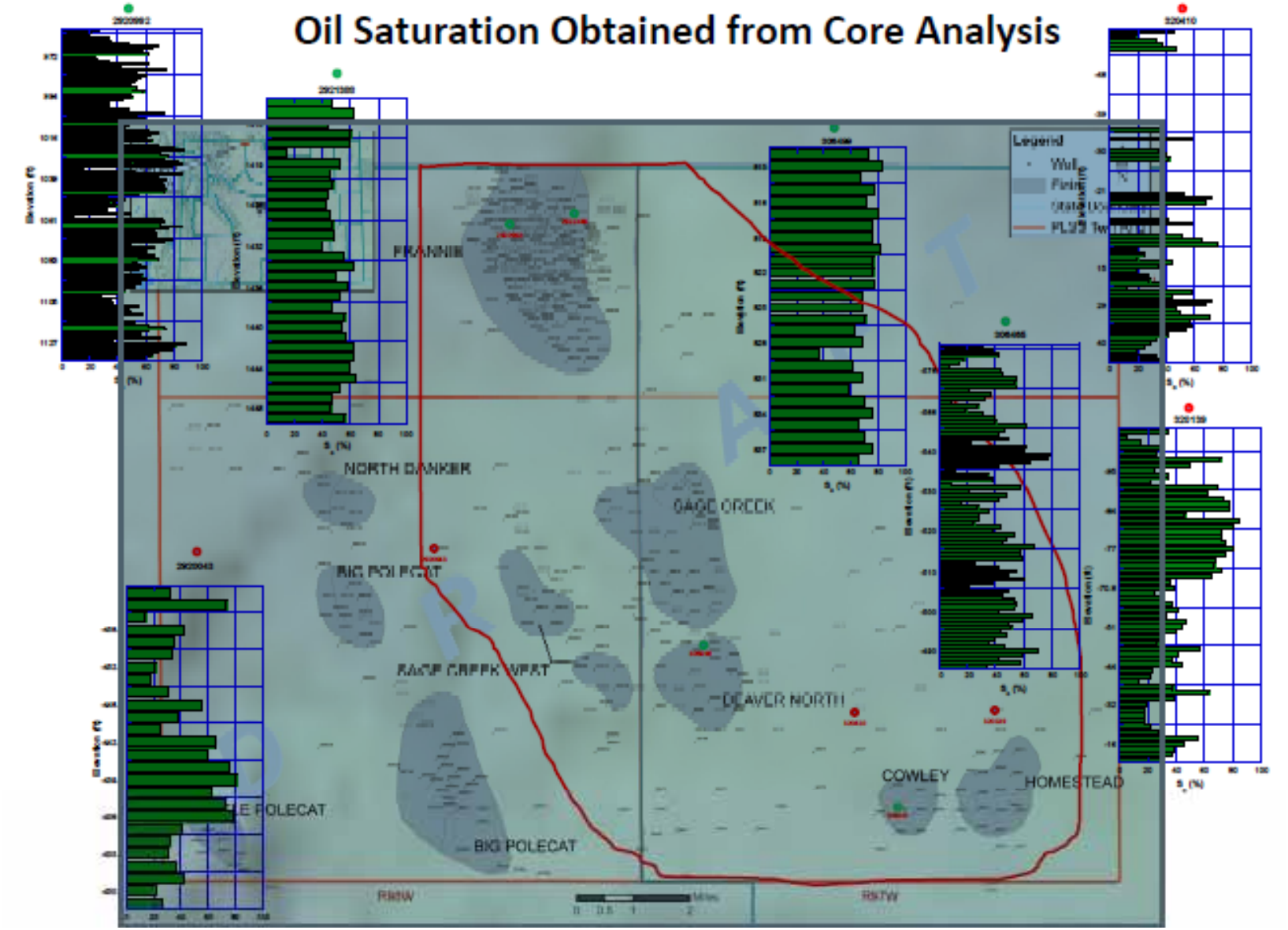
GLSAU Geologic Model



Core Saturation



Wyoming – Big Horn Basin
Ten Sleep Formation



One of the “Other“ basins we are looking at for ROZ potential

ARI estimated TZ/ROZ OIP in 13 Bighorn Basin Tensleep Productive reservoirs: 4.4 BBbls

– These 13 Tensleep reservoirs with cumulative production: from 345.4 to 6.2 MMBbls

13 Bighorn Basin Tensleep Reservoirs

	MPZ OOIP (BBbls)	MPZ Remaining OIP (BBbls)	TZ/ROZ OIP (BBbls)	Total Reserve for CO_2-EOR (BBbls)
1. CO_2-miscible fields: 8 2. CO_2-immiscible fields: 5	4.5	3.1	4.4	7.5
CO_2-EOR recovery: 11%		0.34	0.48	0.82
CO_2-EOR recovery: 30%		0.93	1.32	2.25

OVERVIEW OF THE ELEMENTS OF CCS (& CO_2 EOR + CCS)

Presented by the Applied Petroleum Technology Academy
(www.aptapb.org)

and Petroleum Technology Transfer Council
(http://www.pttc.org/)

and the American Association of Petroleum Geologists
(http://www.aapg.org/)

Texas Railroad Commission Building
1701 N. Congress
Austin, Tx

June 15, 2011

Overview of the Elements of CCS

Topics to be Covered Today

AM *

1. EOR and CCS Industry Overview……Trentham
2. Existing CO_2 Markets……Trentham
3. CO_2 EOR and the Baseline for CCS……Trentham
4. Synergies of Carbon Management and EOR……..Trentham/Rychel
5. Properties of CO_2……..Trentham
6. CO_2 Sources & Capture Technologies……..Rychel
7. Ongoing Research……Rychel
8. Transportation and Metering……Trentham
9. Injection Projects……Trentham/Rychel
10. Reservoir Considerations..……Trentham

PM *

11. CO_2 Operations……..Trentham
    A. Downhole Equipment, Considerations
    B. Surface Facilities and Process Flow
12. Monitoring, Verification, and Accounting (Surveillance)…..Rychel
13. Regulatory Frameworks and The ‘Bidness’ of CO_2 ……Trentham

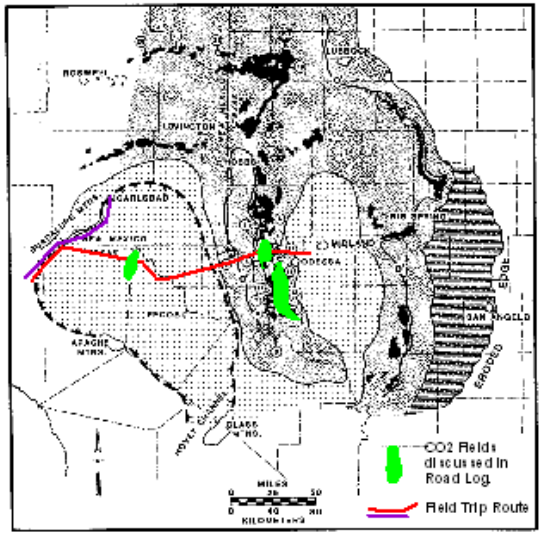
** If all goes well*

Student CCS Modules Project

Road Logs,
Plant and Field descriptions
Core from CO2 fields

2010
Carbon Capture and Storage Field Trip
Odessa – Kermit – Orla – Salt Flat - Carlsbad
By Bob Trentham
Modified from road logs by Bob Lindsay, Bob Ward and Bob Trentham & Peter Scholle.

Interval Mileage	Cumulative Mileage	Description



PERMIAN
LOWER GUADALUPIAN SERIES
SAN ANDRES FORMATION

Welcome to the Carbon Capture and Storage Field Trip to the Guadalupe Mountains. Today, we will leave the Center for Energy and Economic Diversification located at the intersection of SH 191 and FM 1788 in western Midland County between Midland and Odessa and head west on SH 191 through Odessa. We will then be driving west on SH 302 thru Notrees, Kermit and Mentone. Turn north on US 285 to Orla and west on FM 652 to US 62 /180, west/south on US 62/180 to Pine Spring and the Salt Flat Graben. Then backtrack to Carlsbad.

On this trip we will be reviewing the Permian Guadalupian basin and shelf deposits in the Delaware and Guadalupe Mountains and the utilization of CO2 in Enhanced Oil Recovery project in the Permian Basin. CO2 has been utilized in Enhanced Oil Recovery projects in the basin for the past 40 years. Today, 4 billion cubic feet of CO2 is "handled" daily in over 60 producing oil fields. Over