

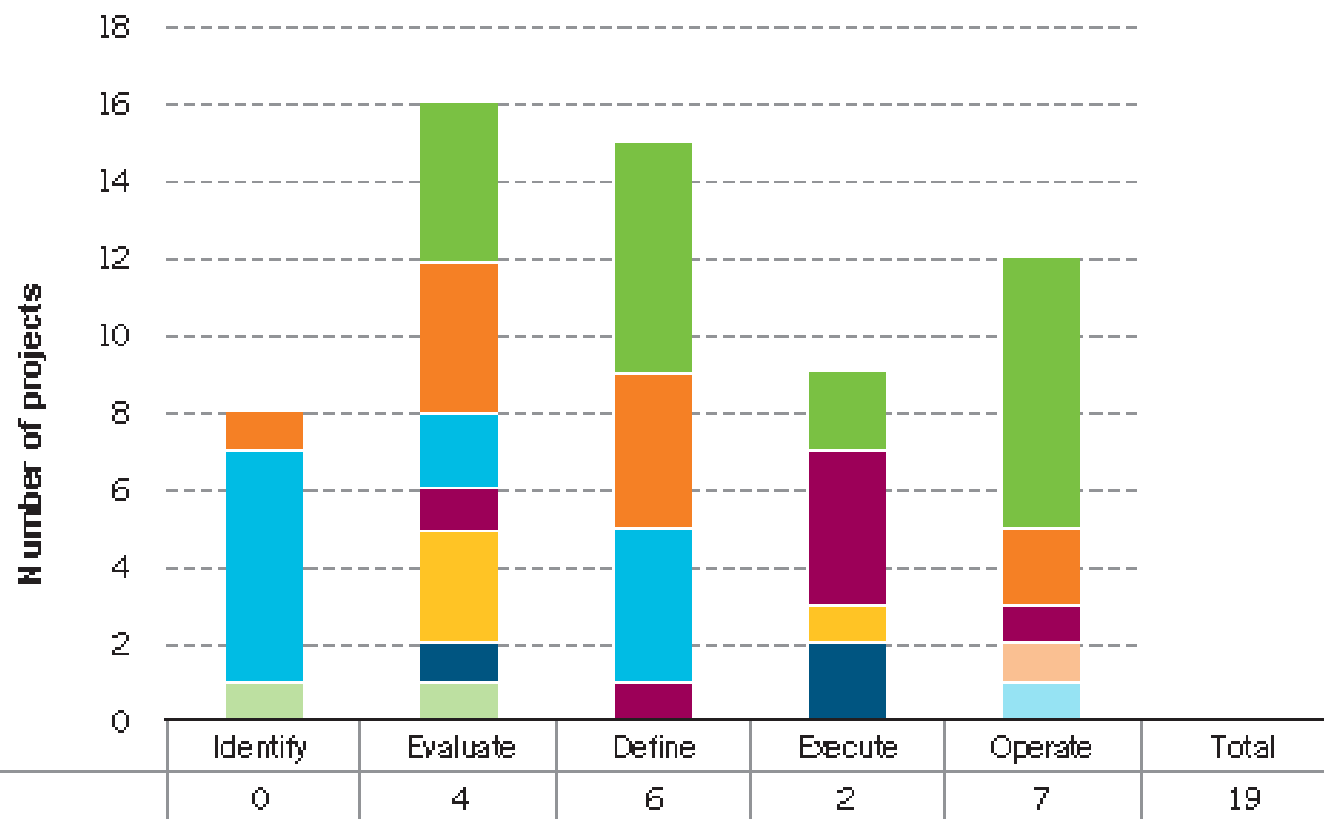
US Geologic Storage Projects with examples from Gulf Coast Carbon Center Research

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Gulf Coast Carbon Center
Bureau of Economic Geology
The University of Texas at Austin

Presented at the
CAGS Workshop
May 13, 2014



Status of US Projects



A theme of variation

Project	Capture from	Storage	Status
IBDP	Ethanol	Saline Basal Cambrian	underway
ADM	Ethanol	Saline Basal Cambrian	Permit pending
FutureGen2	Coal oxyfire	Saline Basal Cambrian	seeking financial closure
Air Products	Refinery H ₂ reformer	EOR -Frio	underway
Southern Plant Barry	Coal Post combustion amine	Saline in Citronnel oil field	Underway
Bell Creek	Gas separation	EOR- Muddy	underway
Kemper County	Coal gasification	EOR-various	In construction
NRG	Post combustion	EOR-Frio	seeking financial closure
Leucadia Lake Charles	Pet Coke gasification	EOR-Frio	seeking financial closure
Summit	Coal gas/urea	EOR-Permian basin	seeking financial closure

DOE-funded capture-to-storage projects

Gulf Coast Carbon Center (GCCC)



BEG Team
Scott Tinker
Michael Young
Sue Hovorka
Tip Meckel
J. P. Nicot
Rebecca Smyth
Ramon Trevino
Katherine Romanak
Seyyed Hosseini
Changbing Yang
Vanessa Nunez
Dave Carr
Brad Wolaver
Alex Sun
Jiemin Lu
students and others

Collaborators



LBNL
LLNL
ORNL
NETL
SNL
Mississippi State U
U of Mississippi
SECARB
UT-PGE
UT Chem-E
CFSES- BES
UT- CIEEP
UT- DoGS
UT- LBJ school
BEG- CEE
JSG – EER
Univ. Edinburgh
Univ. Durham
RITE
CO2-CRC

IA sponsors



UT - large CCS program



Gulf Coast Carbon Center at
the Bureau of Economic Geology,
Jackson School of Geosciences

Luminant Capture Program
Department of *Chemical
Engineering*

Geological CO₂ Storage JIP
Center for Petroleum and
Geosystems Engineering
Cockrell School of Engineering

Structure of GCCC Research

**GCCC
Major Themes
2011-2014 Plan**

Major Funded Projects

GCCC Industrial Associates

**Sponsor and CCP
funded projects**

Analog Studies

DOE-Offshore Miocene

**Links to
CCS JIP**

**Capacity
Estimation**

DOE SECARB – Phase III

**Links to
Capture**

**Unconventional
EOR**

DOE AP/LLC-Hastings EOR

**Links to
BES
CFSES**

**Value of
Information**

**Petranova: NRG – West
Ranch**

**Links US
and
global**

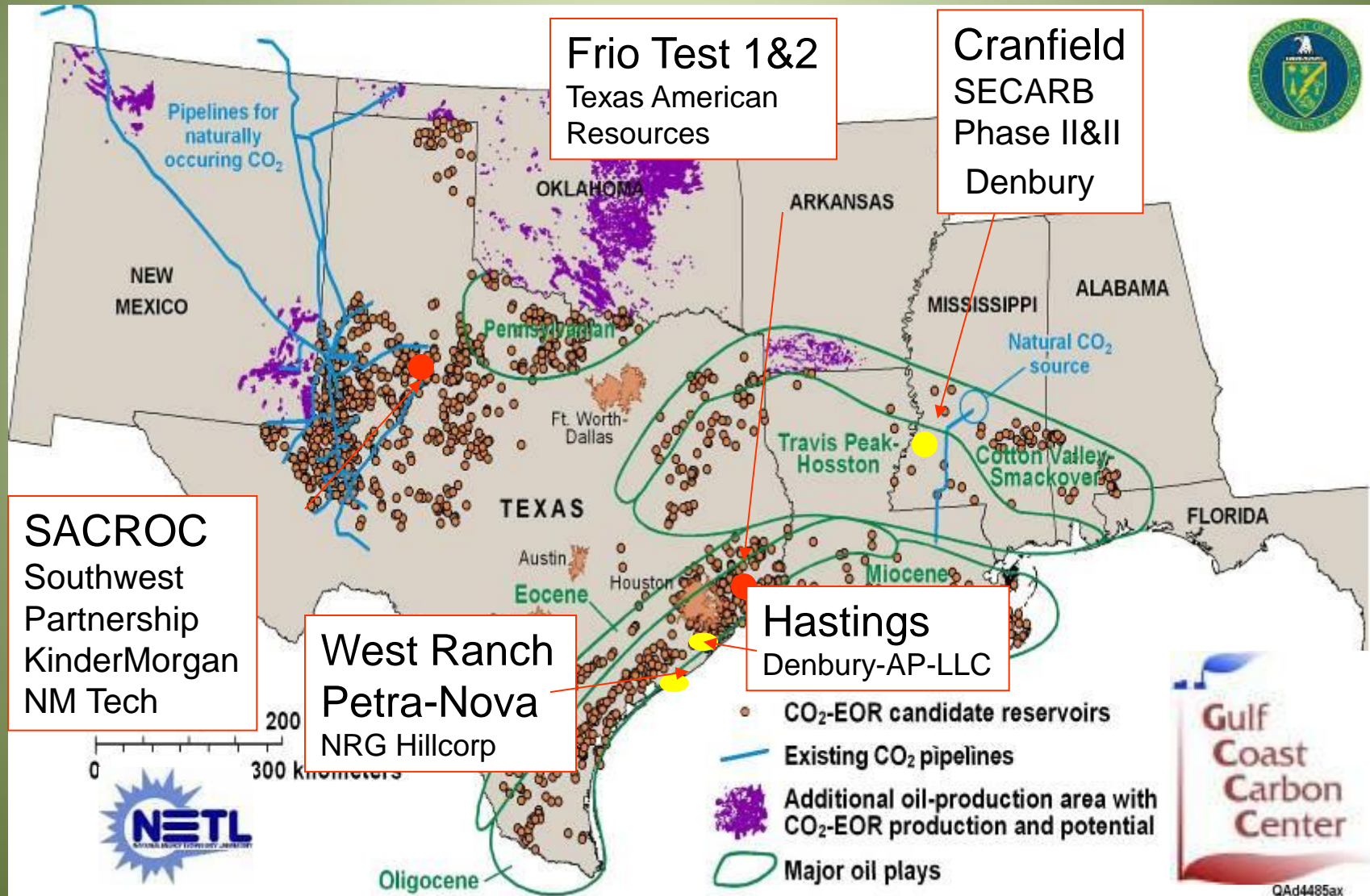
**Knowledge
Sharing**

EPA-CCP-Site-specific

BOEM offshore regulations

“STORE “ Outreach

GCCC DOE-Funded Field Monitoring Programs



Frio 1 2004-2006

Context:

- 1600 tones CO₂-A
- 1500 m deep sandstone - saline

Funded by NETL

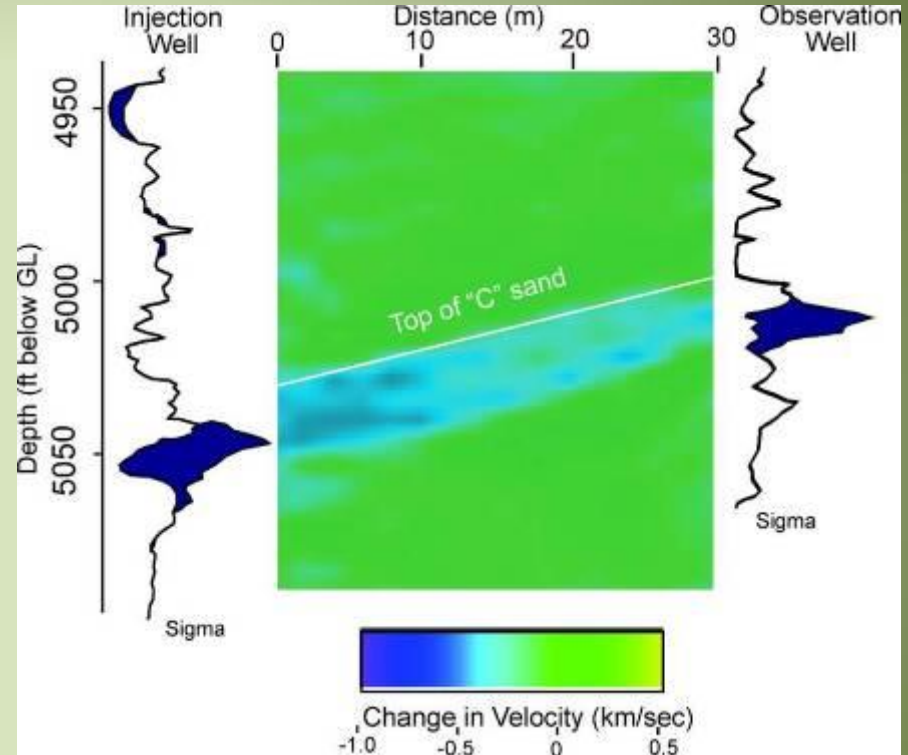
Lead: Hovorka/Geo-SEQ

Host:

Texas American Resources

Key results:

- First US saline test
- Residual saturation trapping
- Long post injection monitoring-
- U-Tube development



Frio Cross –well and RST time lapse difference 2 months post injection
BEG-LBNL(Geo-Seq)

May 2009 VSP – CO₂ still trapped!
Residual trapping @15 degrees dip, 1 Darcy permeability

Frio 2 2006-2009

Context:

- 300 tonnes CO₂-N
- 1570 m deep 2D sandstone

Funded by NETL

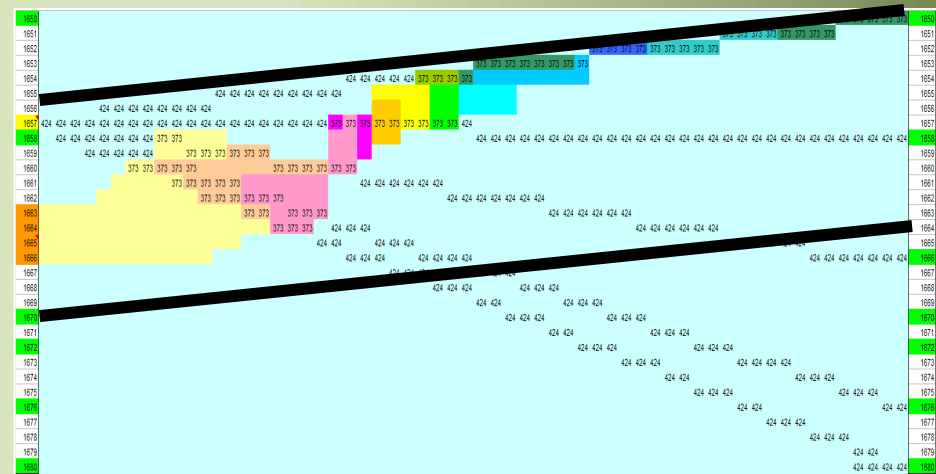
Lead: Hovorka/Geo-SEQ

Host:

Texas American Resources

Key results:

- Gravity-heterogeneity interaction
- Long post injection monitoring- VSP
- Continuous Active Seismic Source developed



Plume Evolution tracked with CASSM
2.5 day migration - rise + fast path in
heterogeneous fluvial sandstones and
gravels (LBNL)

SACROC 2005-2008

Context:

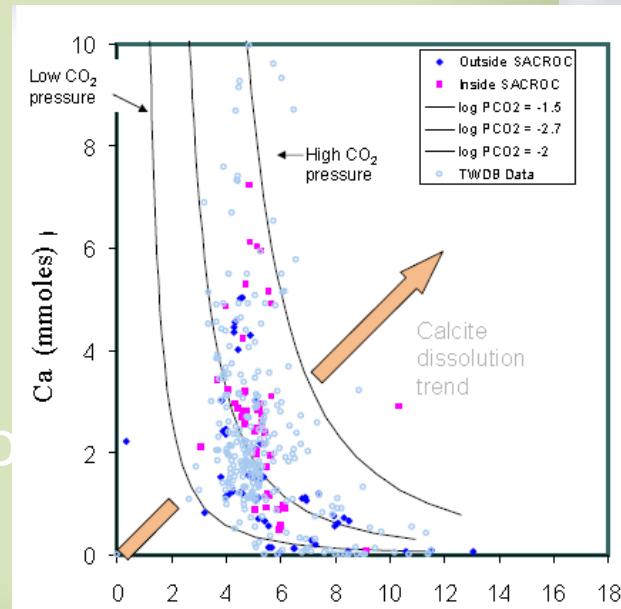
- 80 Million tonnes stored CO₂-N+A/37 years
- 2000 m deep-carbonate
- Southwest Partnership

Lead: Smyth and Romanak

Host: KinderMorgan

Key results:

- No CO₂ related damage to freshwater after 37 years injection
- Sensitivity to leakage — Two years sampling significant groundwater resource Romanak-Smyth
 - site specific
 - rock-water interaction



Cranfield Phase II (EOR) 2008-2013

Context:

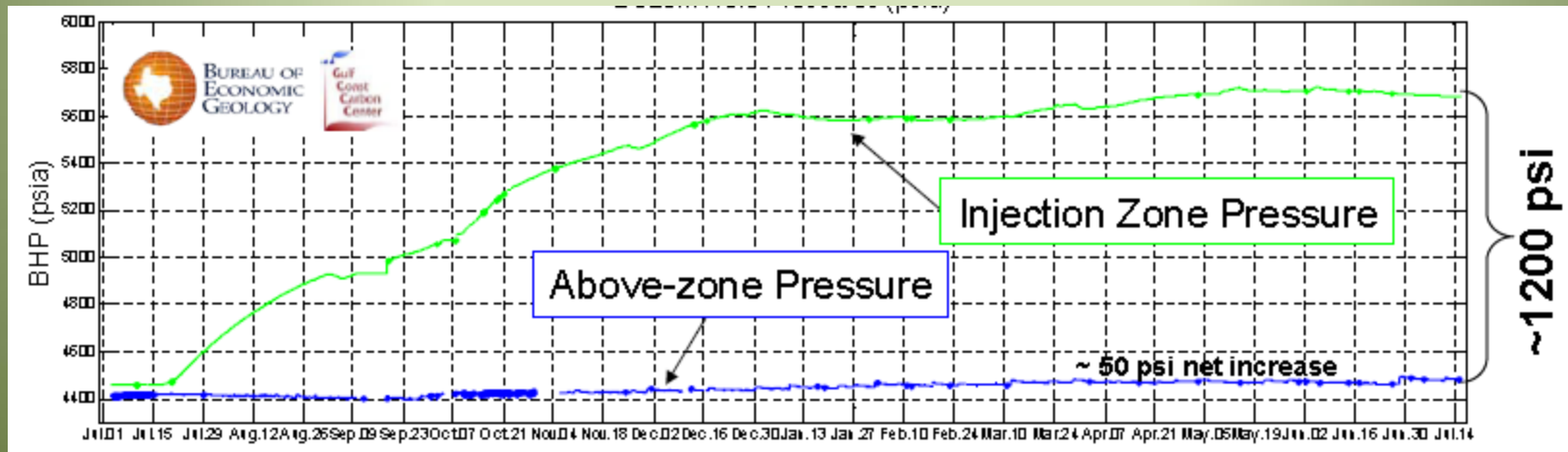
- 1 Million tonnes CO₂-N
- 3000 m deep fluvial sandstone
- SECARB Partnership (SSEB)

Lead: Hovorka, Meckel

Host: Denbury Onshore LLC

Key results:

- Develop above zone pressure monitoring interval (AZMI) test vertical isolation



Pressure measurement in 3 m-100 md regional ly extensive sandstone
100 m above injection zone – assess isolation Meckel

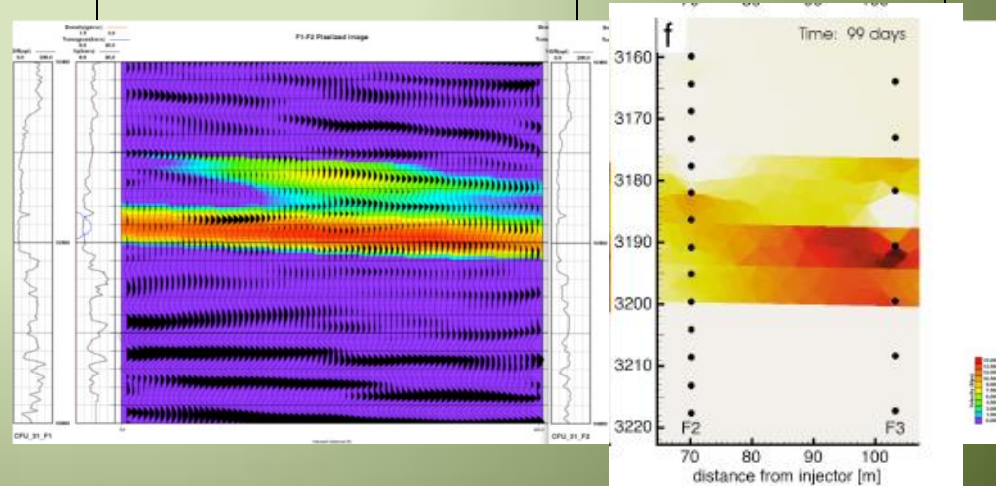
Cranfield Phase III (stacked) 2009- continuing

Context:

3 Million tonnes CO₂-N
3000 m deep fluvial
sandstone (brine)
SECARB Partnership (SSEB)
Lead Hovorka, Meckel, Trevino
Host: Denbury Onshore LLC

Key results:

Time and space evolution
of saturation
ERT for CCS LLNL



Schlumberger cross-well LBNL inversion ERT

Air-Products & Leucadia Lake Charles Hastings 2011-2015

Context:

Planned 5 Million tones CO₂- A + 8

Million tons CO₂ N

2000 m deep fluvial
sandstone (EOR)

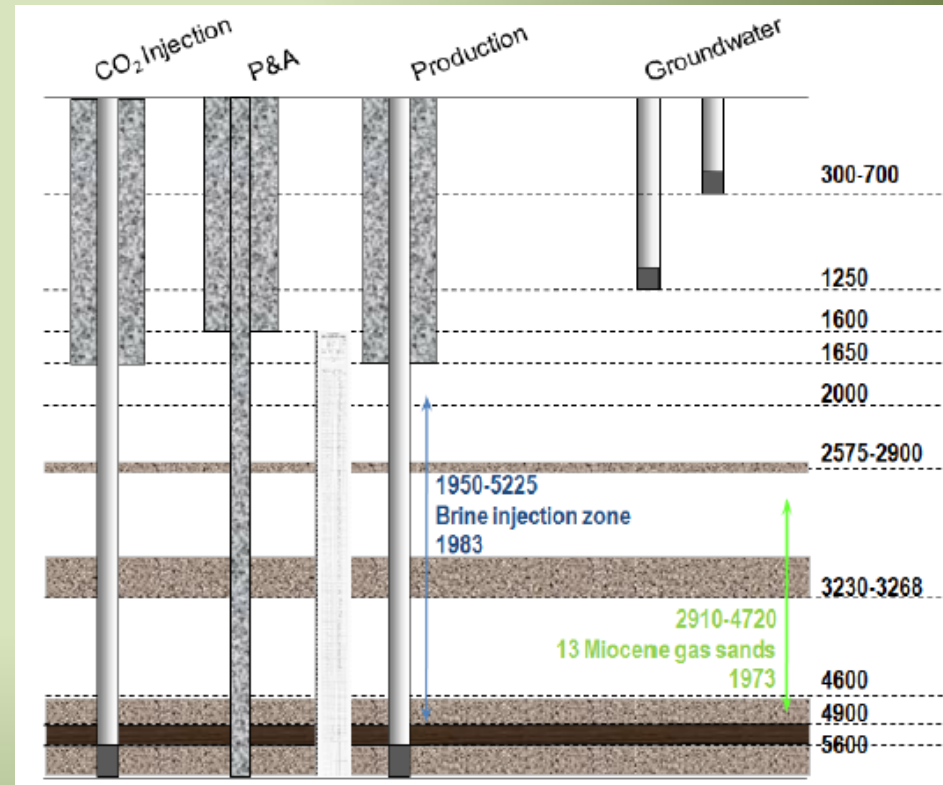
Lead; Nunez, Hovorka

Host: Denbury Onshore LLC

Key results:

Test best commercial
technologies for confirming
storage permanence in EOR
context

Assessment of faults



Well risk factor assessment - Wolaver

Petra Nova NRG JW Parrish Plant 2012-2017

Context:

Planned multi million tonnes CO₂- A
from coal-fired capture

2000 m deep

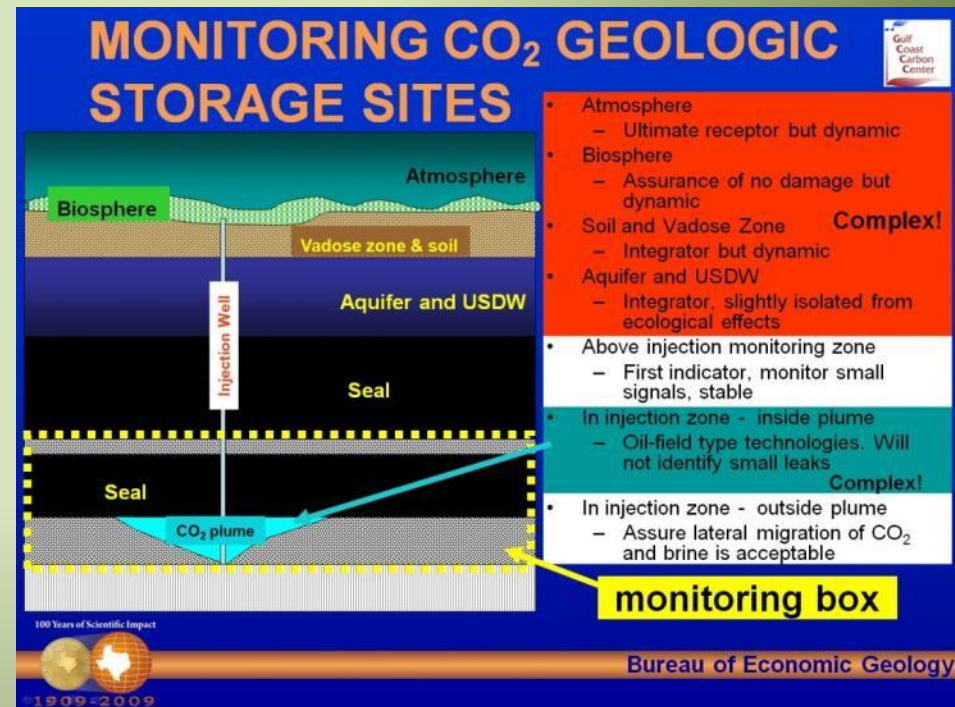
bar sandstones (EOR)

Lead: Smyth

Host: Hillcorp at West Ranch

Key GCCC results:

Test best commercial
technologies for confirming
storage permanence in EOR
context



Offshore Miocene Study



Planned Keystone XL
pipeline

DRI CO₂ Pipeline

HOUSTON



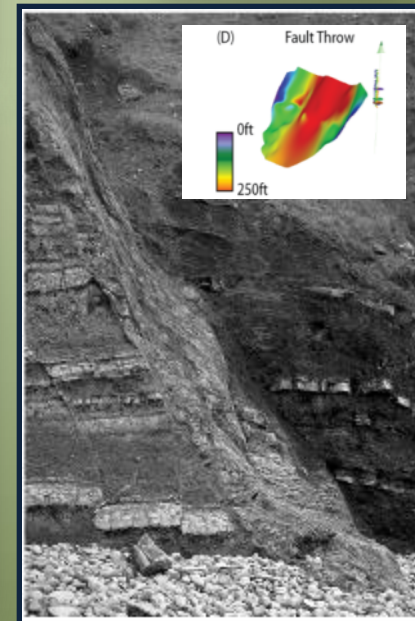
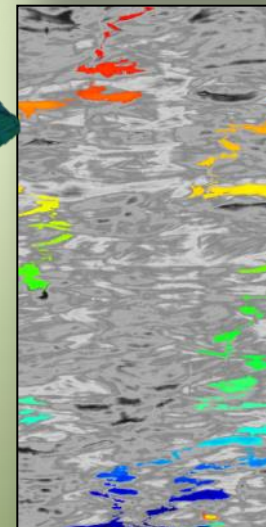
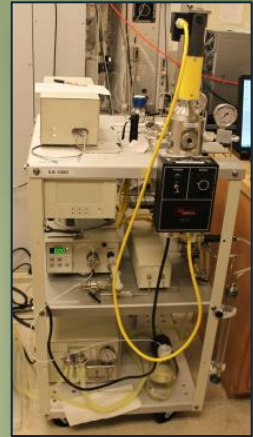
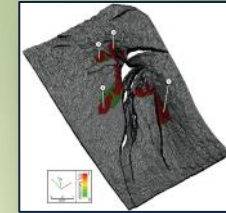
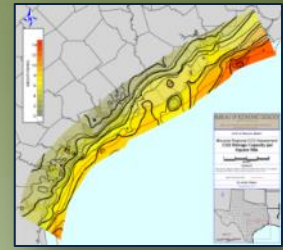
Tip Meckel and Ramon Trevino

DATE	TX LOCATION	AREA (sq. km.)	LINE KM	AIRGUN SOURCE
July, 2012	San Luis Pass	58	1,077	Two 210 cu. in. GI
October, 2013	San Luis Pass	31.5	420	One 90 cu. in. GI
April, 2014	High Island	38.5	626	Two 90 cu. in. GI

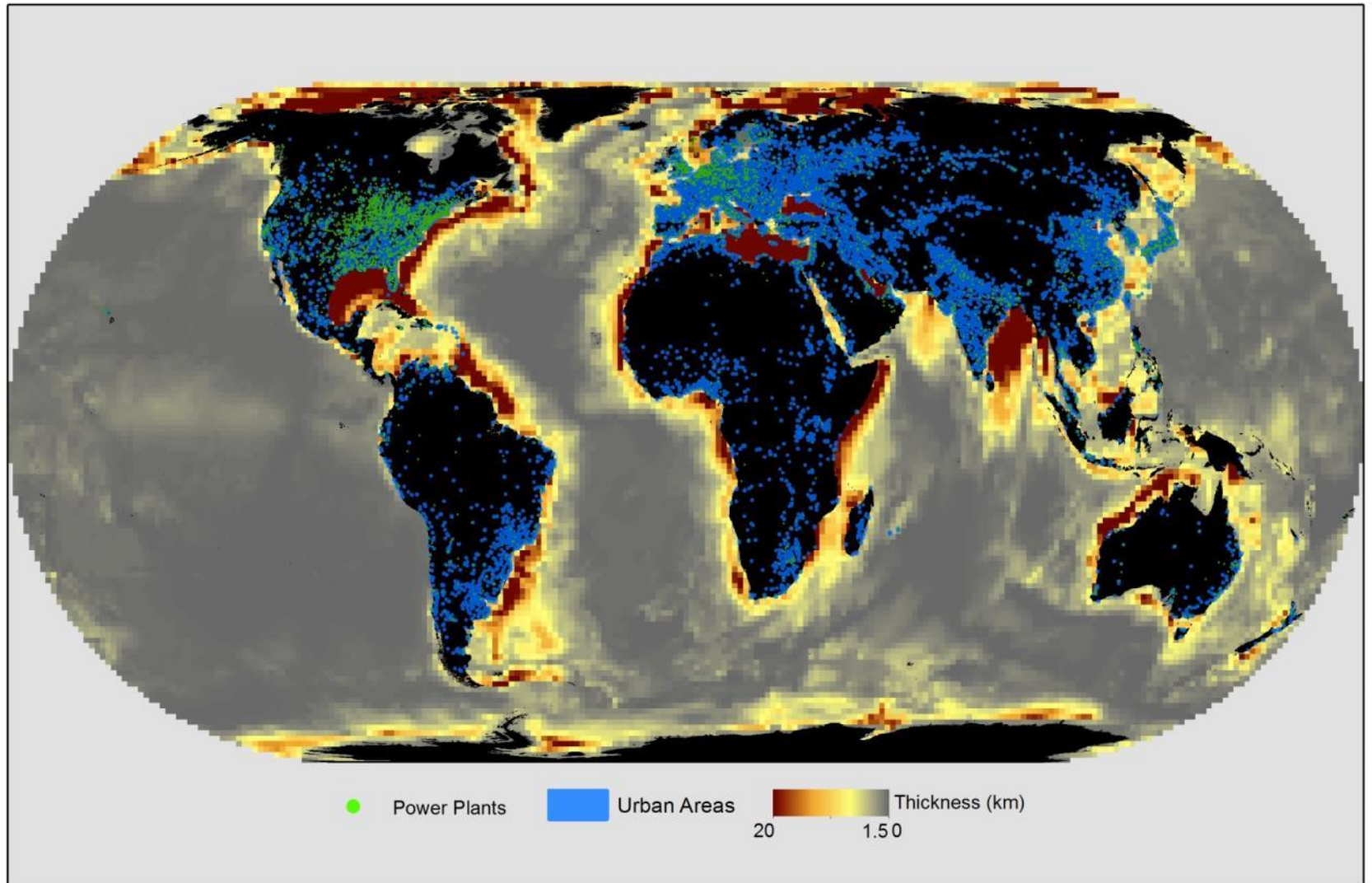


Offshore Project Research Scope

- Static capacity calculations
- Dynamic capacity calculations
 - Analytical & geocellular modeling
- Geochemistry
- Mudrock sealing capacity
- Fluid migration, saturation
- Fault seal
- High resolution 3D seismics

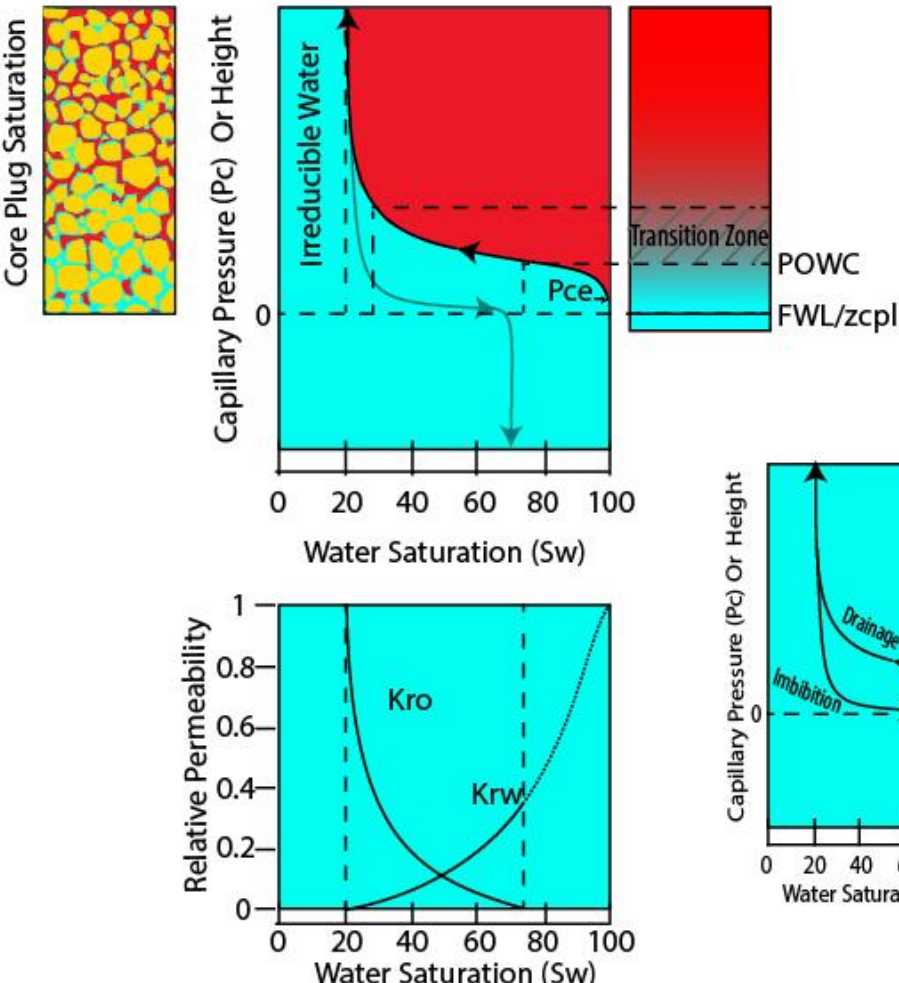


Global Subsea Geologic Storage Capacity

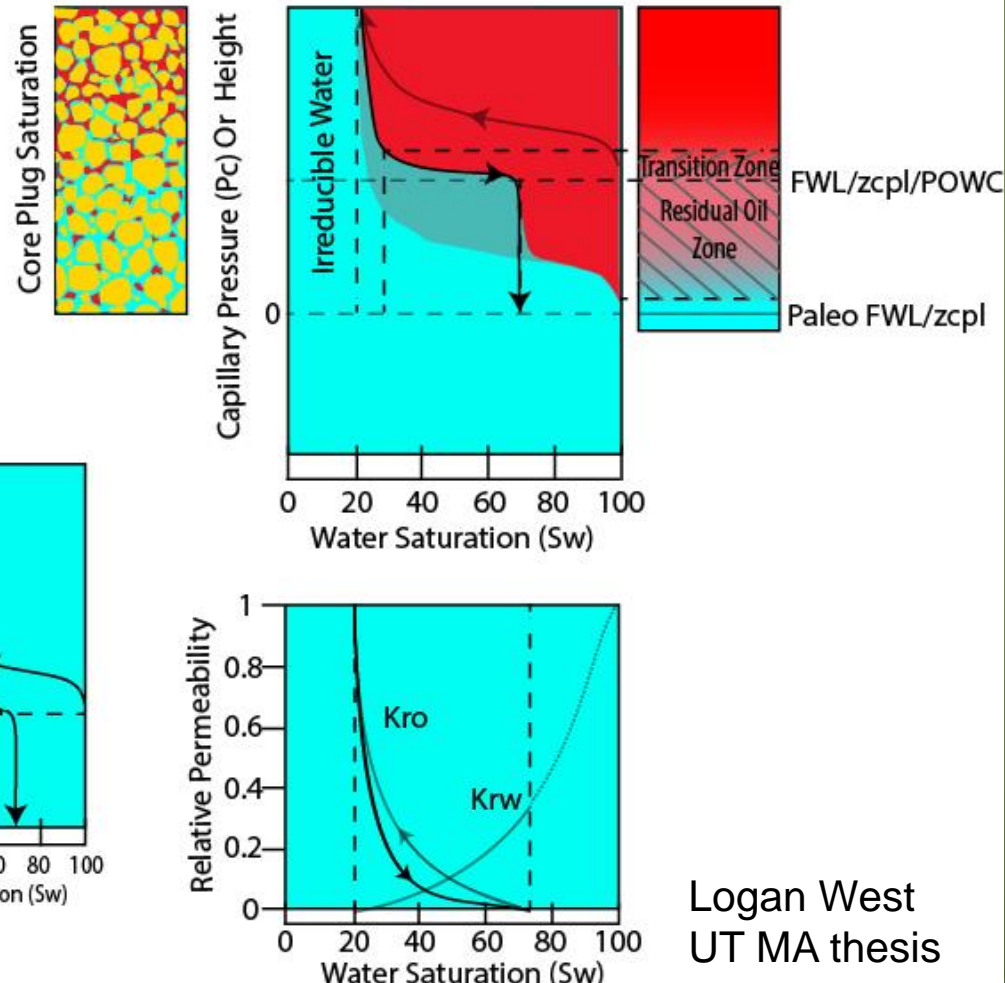


Residual Oil zones: Significant resource producible only by EOR

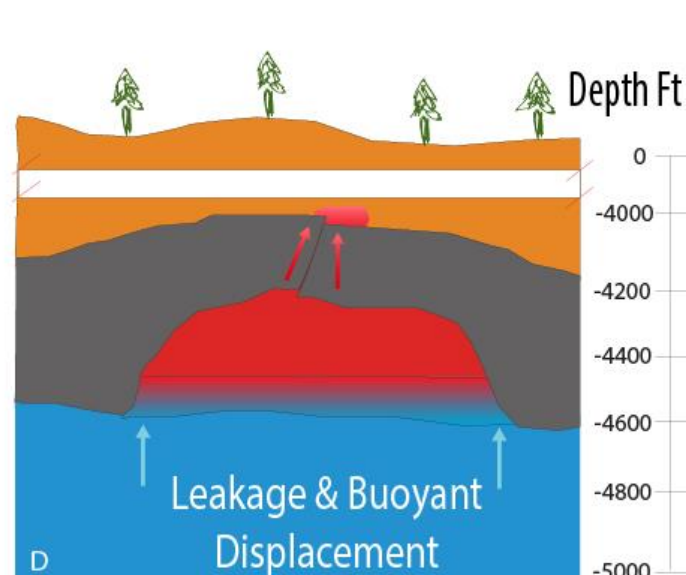
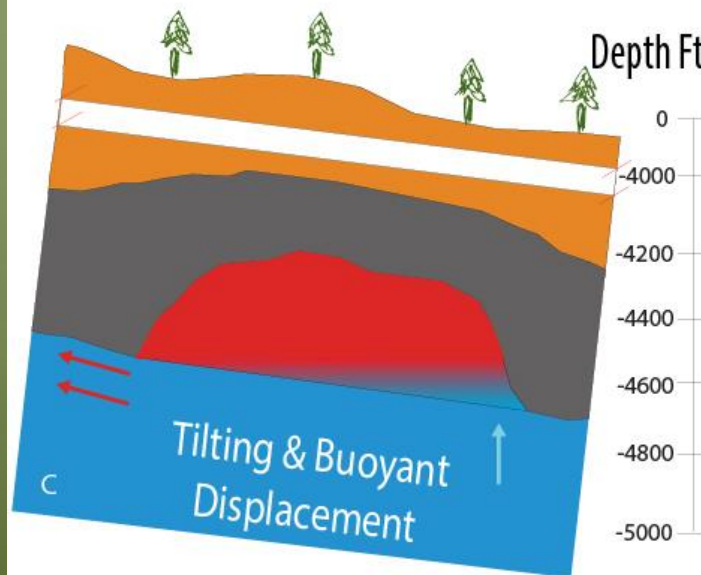
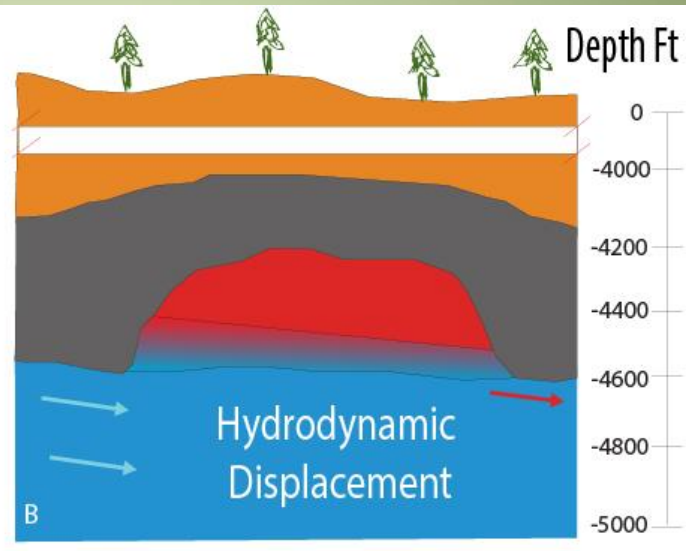
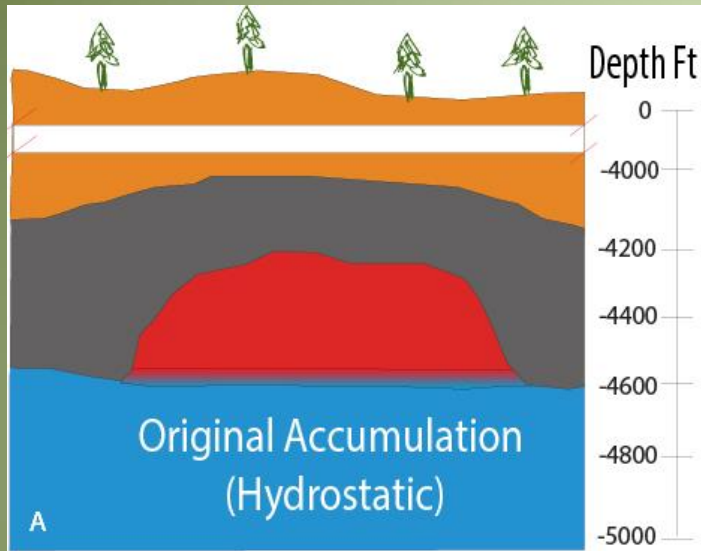
Original Accumulation (Drainage)



Post Oil Displacement (Imbibition)



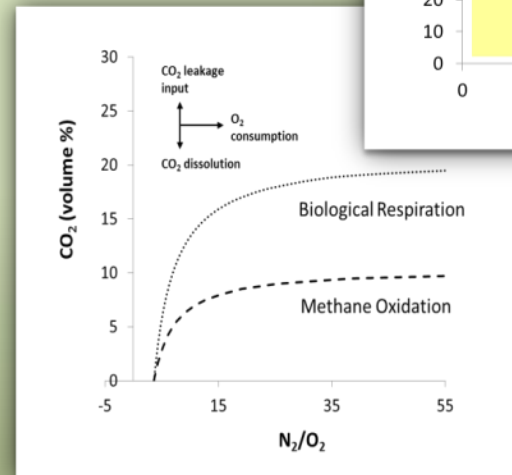
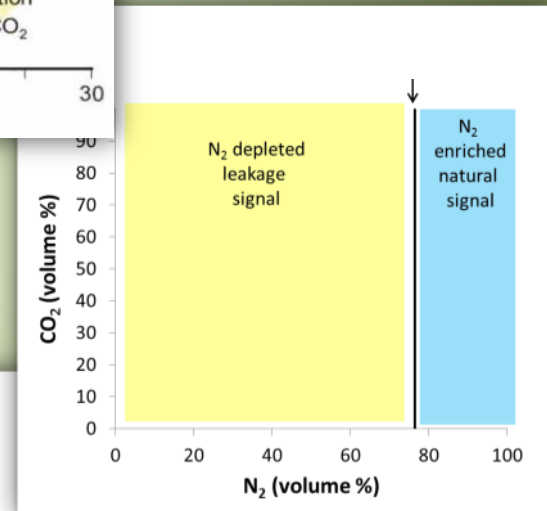
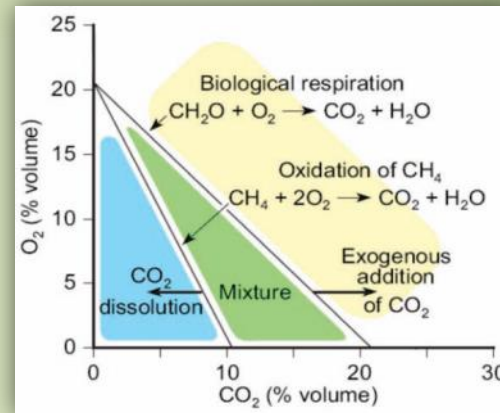
Origin of ROZ: possible in many basins



Process-Based Soil Gas Method

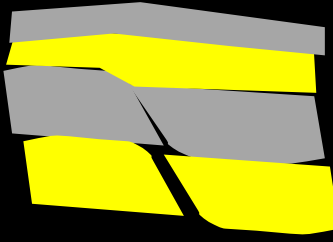
- Does not rely on background CO_2 measurements
- Uses ratios among simple gases (CO_2 , CH_4 , N_2 , O_2)
- Discerns process
 - In-situ from exogenous gas
 - Mixing with air
 - CO_2 dissolution
 - Oxidation of CH_4 into CO_2
 - Important for CCUS monitoring

Katherine Romanak

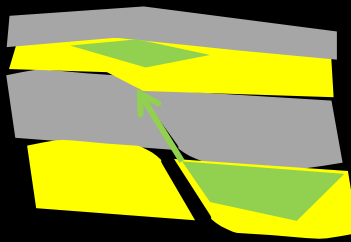


EPA STAR –CCP Site specific monitoring

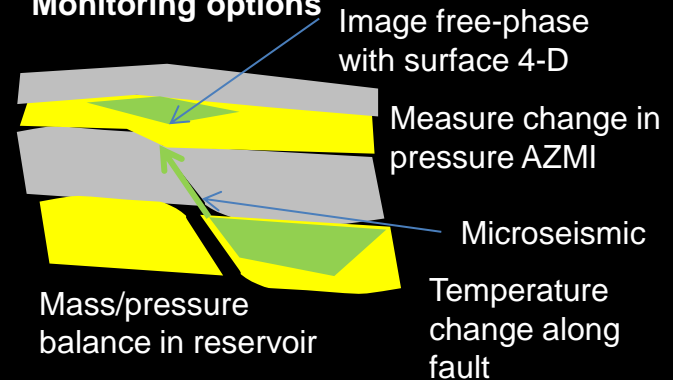
Characterization Uncertainty: Fault-seal??



Leak path concept



Monitoring options



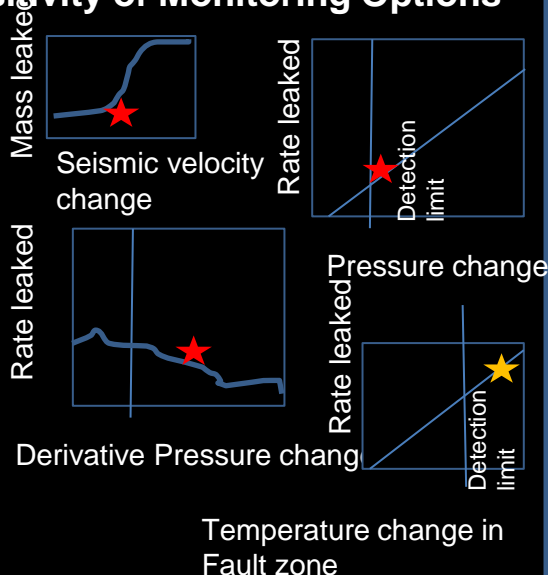
Test Sensitivity of Monitoring Options

Image free-phase with surface 4-D
Measure change in pressure AZMI

Change in rate pressure increase in reservoir

Microseismic

Temperature change along fault



Set triggers, stage monitoring options

- Select microseismic as pre-failure trigger
- AZMI pressure as most sensitive trigger
- Select Image with surface 4-D and change in rate of pressure change in reservoir as post trigger follow up.
- Decrease analysis of microseismic after pressure peaks and plateaus

Knowledge sharing, Public and Technical Outreach

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