

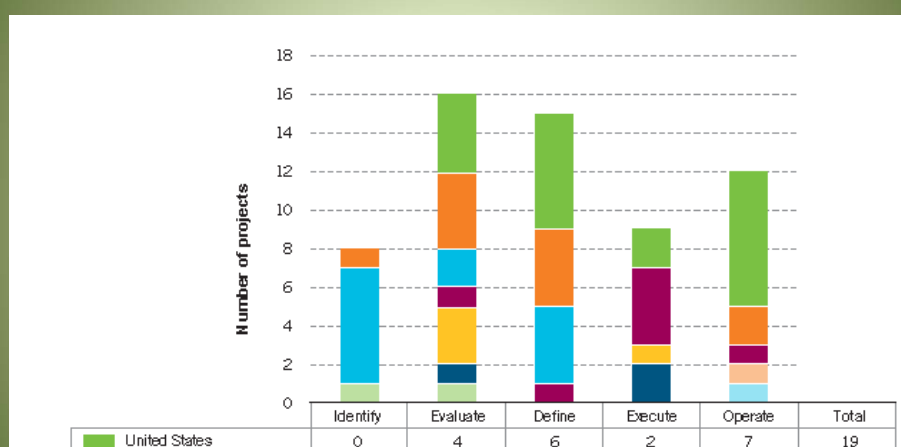
US Geologic Storage Projects with examples from Gulf Coast Carbon Center Research

Susan Hovorka
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



GCCSI, Global Status of CCS 2014

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 combusion amine	Saline in Citronnnel 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	Pet Coke gasification	EOR-Frio	seeking financial closure
Charles 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

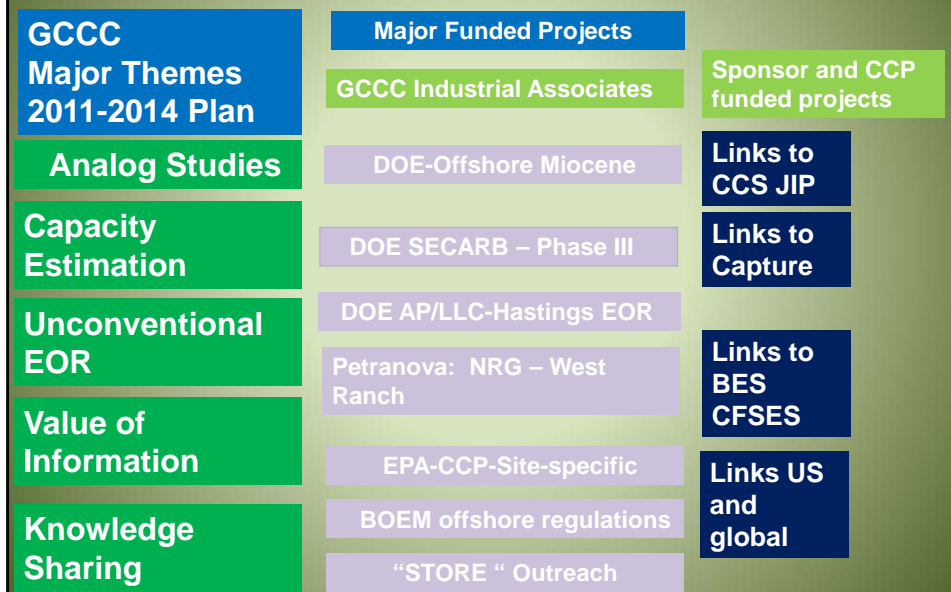


Gulf Coast Carbon Center at
the Bureau of Economic Geology,
Jackson School of Geosciences

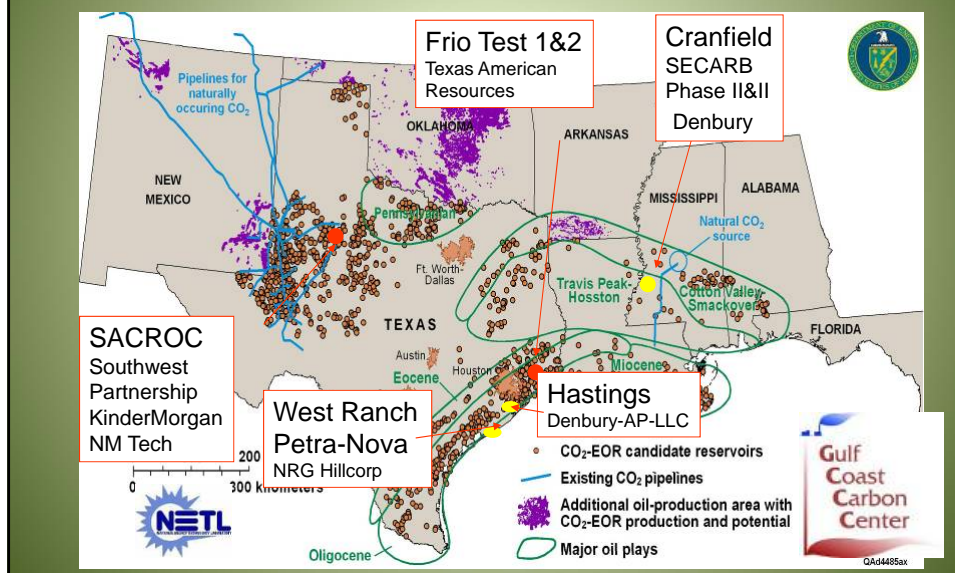
Luminant Capture Program
Department of *Chemical
Engineering*

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

Structure of GCCC Research



GCCC DOE-Funded Field Monitoring Programs



Frio 1 2004-2006

Context:

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

Funded by NETL

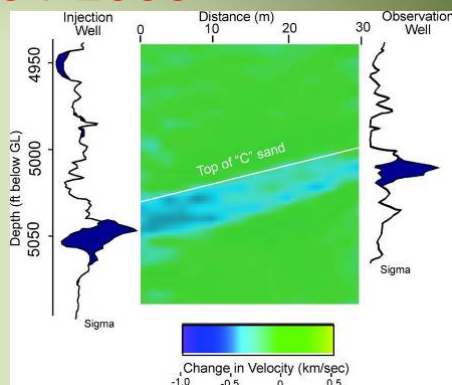
Lead: Hovorka/Geo-SEQ

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 tones 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:

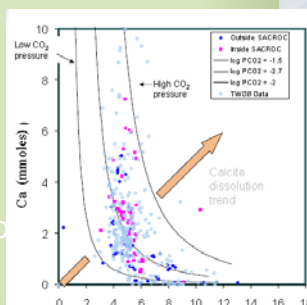
- 80 Million tones stored CO₂-N+A/37 years
- 2000 m deep-carbonate
- Southwest Partnership

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:

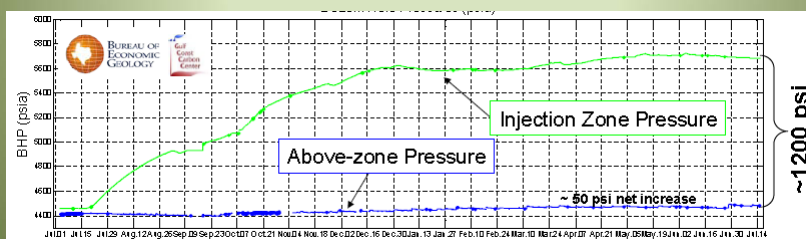
- 1 Million tones CO₂-N
- 3000 m deep fluvial sandstone
- SECARB Partnership (SSEB)

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

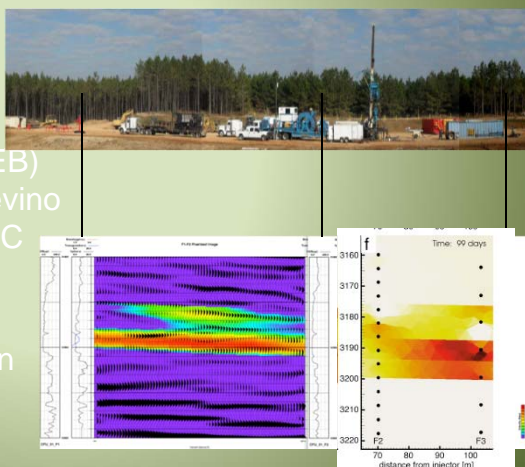
Cranfield Phase III (stacked) 2009-continuing

Context:

3 Million tones 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

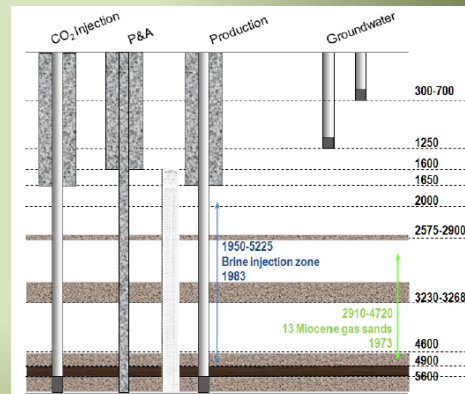
Air-Products & Leucadia Lake Charles Hastings 2011-2015

Context:

Planned 5 Million tons 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

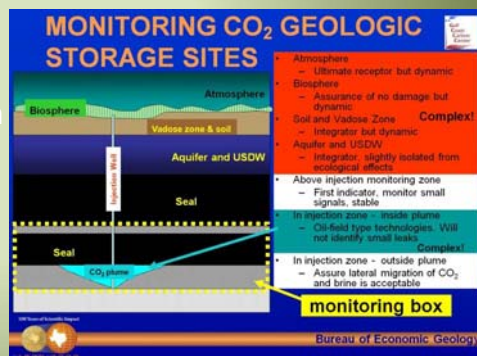
Petra Nova NRG JW Parrish Plant 2012-2017

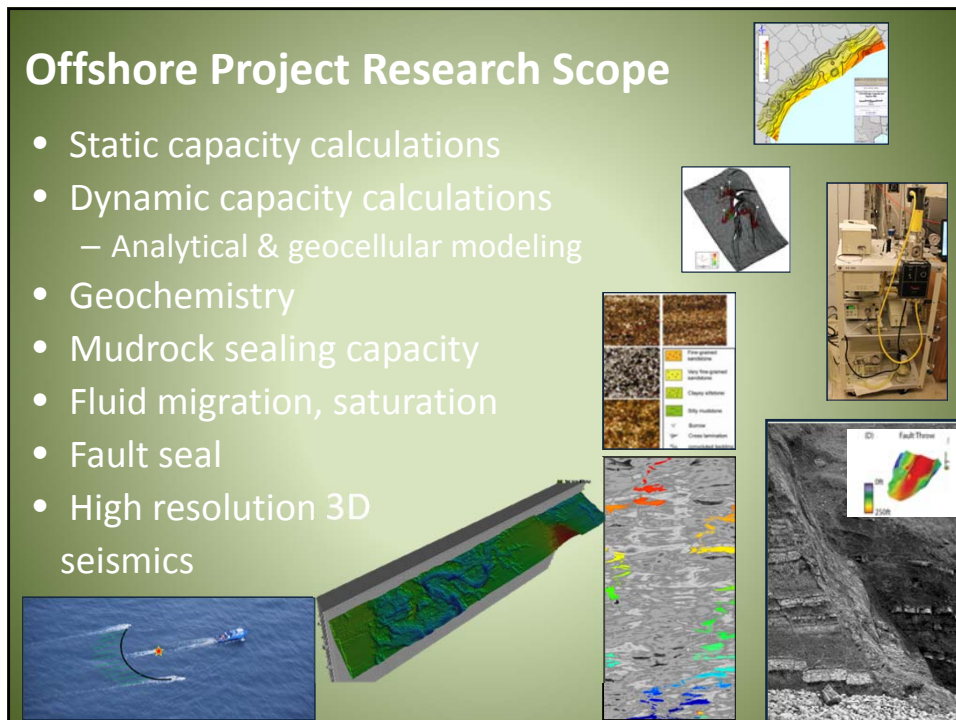
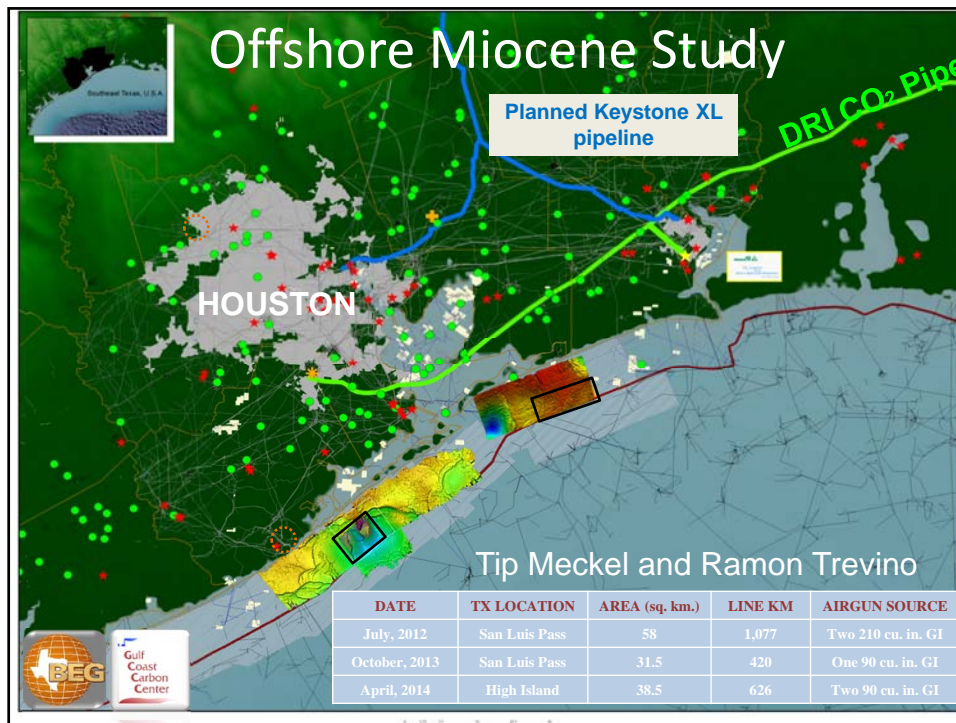
Context:

Planned multi million tones CO₂- A
 from coal-fired capture
 2000 m deep
 bar sandstones (EOR)
 Lead: Smyth
 Host: Hillcorp at West Ranch

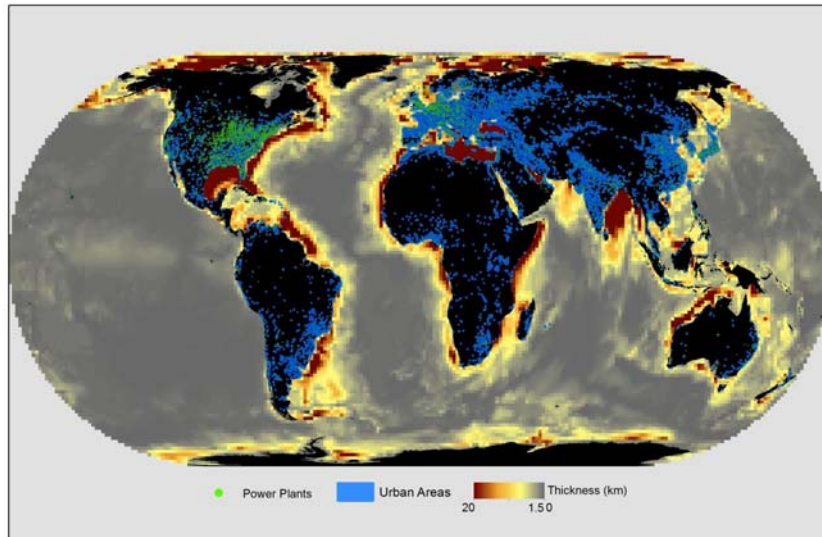
Key GCCC results:

Test best commercial
 technologies for confirming
 storage permanence in EOR
 context

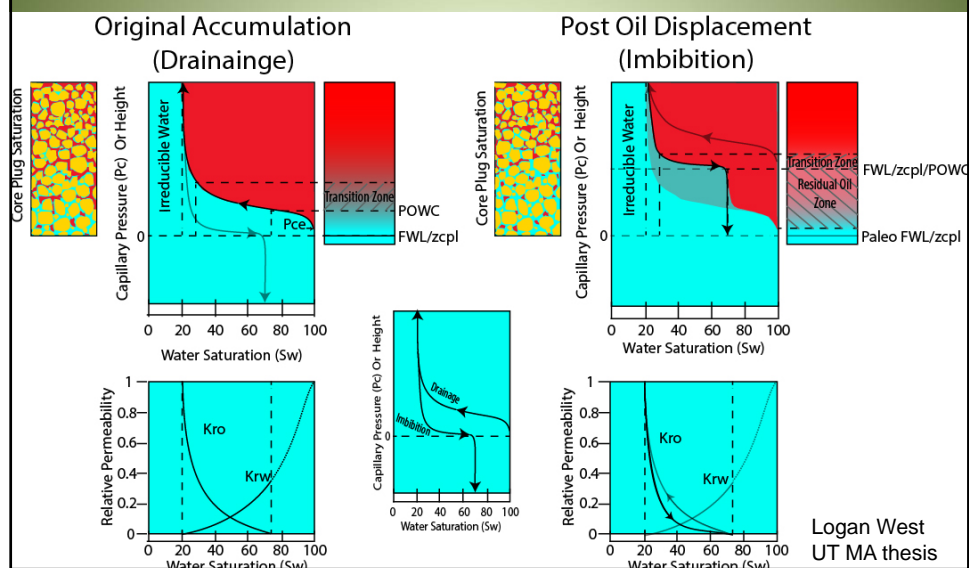




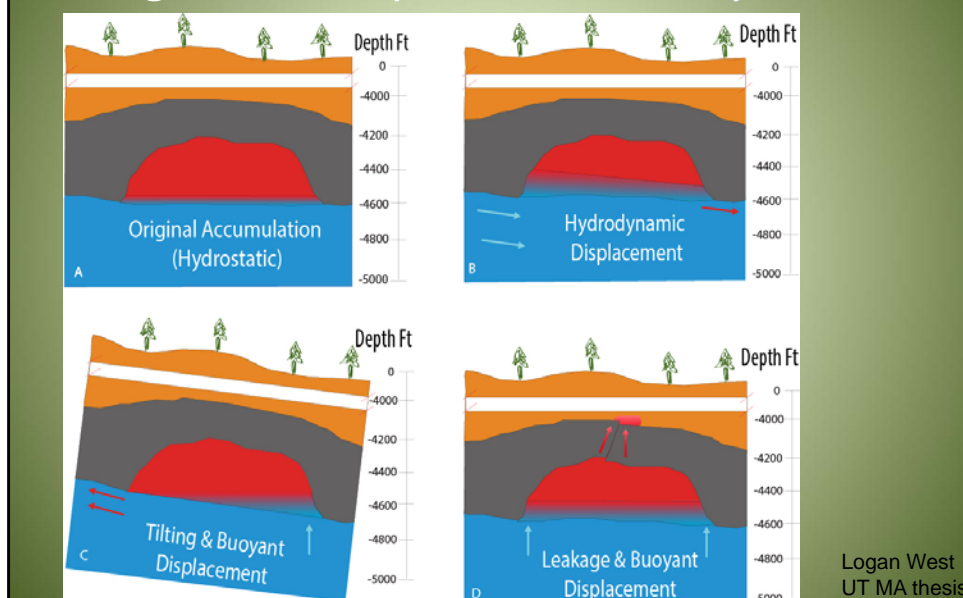
Global Subsea Geologic Storage Capacity



Residual Oil zones: Significant resource producible only by EOR



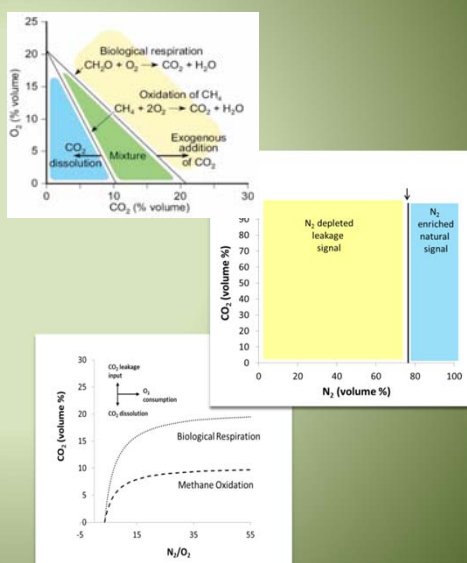
Origin of ROZ: possible in many basins



Process-Based Soil Gas Method

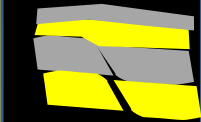
- Does not rely on background CO_2 measurements
- Uses ratios among simple gases (CO_2 , CH_4 , N_2 , O_2)
- Discerns process
 - In-situ from exogenous gas
 - Mixing with air
 - CO_2 dissolution
 - Oxidation of CH_4 into CO_2
 - Important for CCUS monitoring

Katherine Romanak

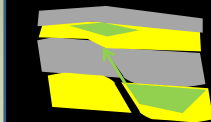


EPA STAR –CCP Site specific monitoring

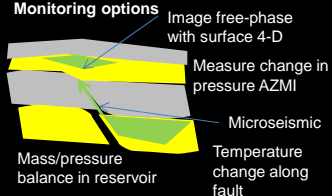
Characterization Uncertainty: Fault-seal??



Leak path concept



Monitoring options

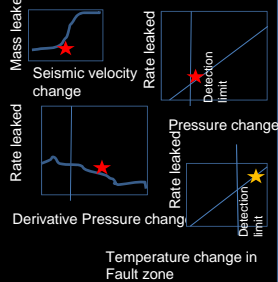


Test Sensitivity of Monitoring Options

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



www.gulfcoastcarbon.org

www.storeco2now.com

See you at GHGT12 in Austin



October 5-9, 2014

Gulf Coast Carbon Center
www.gulfcoastcarbon.org



ExxonMobil

