Partnership for Offshore Carbon Storage Resources and Technology Development in the Gulf of Mexico "GoMCarb"

DE-FE0031558

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Gulf Coast Carbon Center, Bureau of Economic Geology

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https://www.beg.utexas.edu/gccc

U.S. Department of Energy

National Energy Technology Laboratory

Carbon Management Project Review Meeting

August 15 - 19, 2022

Partnership Overview

- Funding
  - DOE: $14 million (5 years)
  - Cost Share: $3.5 million

- Overall Project Performance Dates
  - BP 1 (4/1/2018 → 12/31/20)
  - BP 2 1/1/21 – 3/31/23

- Partnership Objectives
  - Develop / validate technologies & best practices
    - Ensure safe, long-term, economically-viable offshore carbon storage

Partnership Participants

Institution	Location	Expertise
University of Texas at Austin		Project Lead
Gulf Coast Carbon Center	Austin, TX	Geo-Sequestration
Gulf of Mexico Basin Synthesis (GBDS)	Austin, TX	GoM Basin Regional Geology
Petroleum & Geosystems Engineering	Austin, TX	Reservoir Simulation
Stan Richards School	Austin, TX	Public Relations
Aker Solutions	Houston, TX	Subsea Infrastructure
Fugro	Houston, TX	MVA Technologies
TDI-Brooks, Intl.	College Station, TX	MVA Technologies
Lamar University	Beaumont, TX	Risk Assessment; Outreach
Trimeric	Buda, TX	Engineering; Infrastructure & Operations
USGS	Reston, VA	Characterization & Capacity Assessment
Louisiana Geological Survey	Baton Rouge, LA	Database Development
Texas A&M (GERG)	College Station, TX	Ocean & Environmental Science
LBNL (& Rice University)	Berkeley, CA (Houston, TX)	Risk Assessment; MVA Technologies
LLNL	Livermore, CA	Risk Assessment

Overview
Progress and Current Status

- Injecting off-structure viable strategy
- CO_2 marine water dissolution & sea surface dispersion
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- Infrastructure re-use potential
- Critical pressure offshore vs onshore

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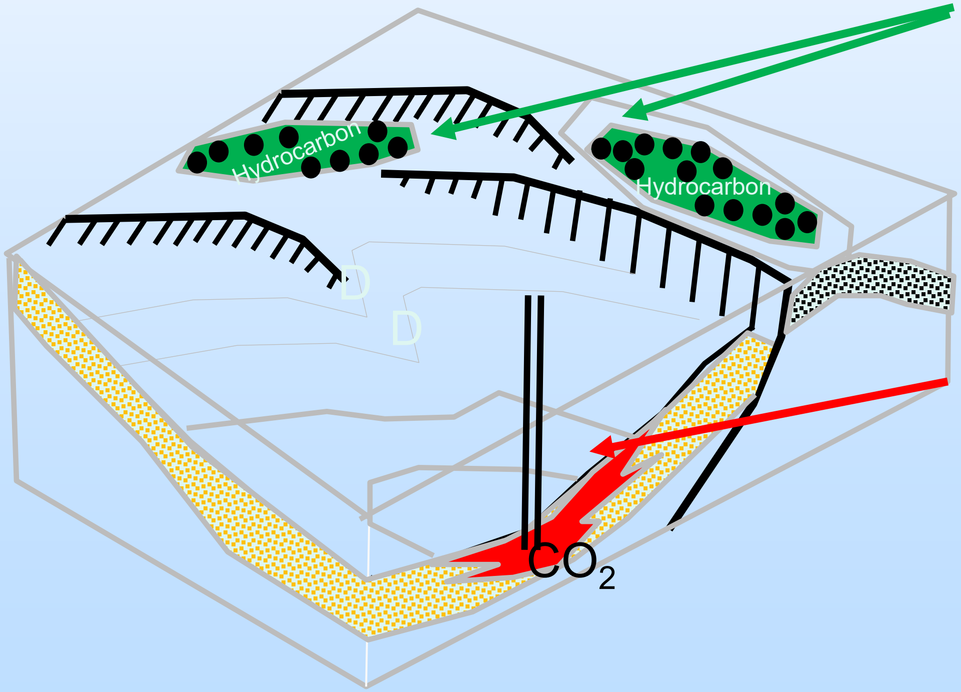
Injecting Off Structure Siting within compartments: Fetch and Trap



- Structural highs = “traps” for buoyant fluids
  - May develop column height of mobile fluids
  - Exploration and production wells
  - May be faulted
  - May have sand pinch out
- “Fetch”
  - In synclinal areas
  - No expectation of hydrocarbons, few penetrations
  - CO_2 will migrate and be trapped by capillary processes
  - May accumulate thick sands

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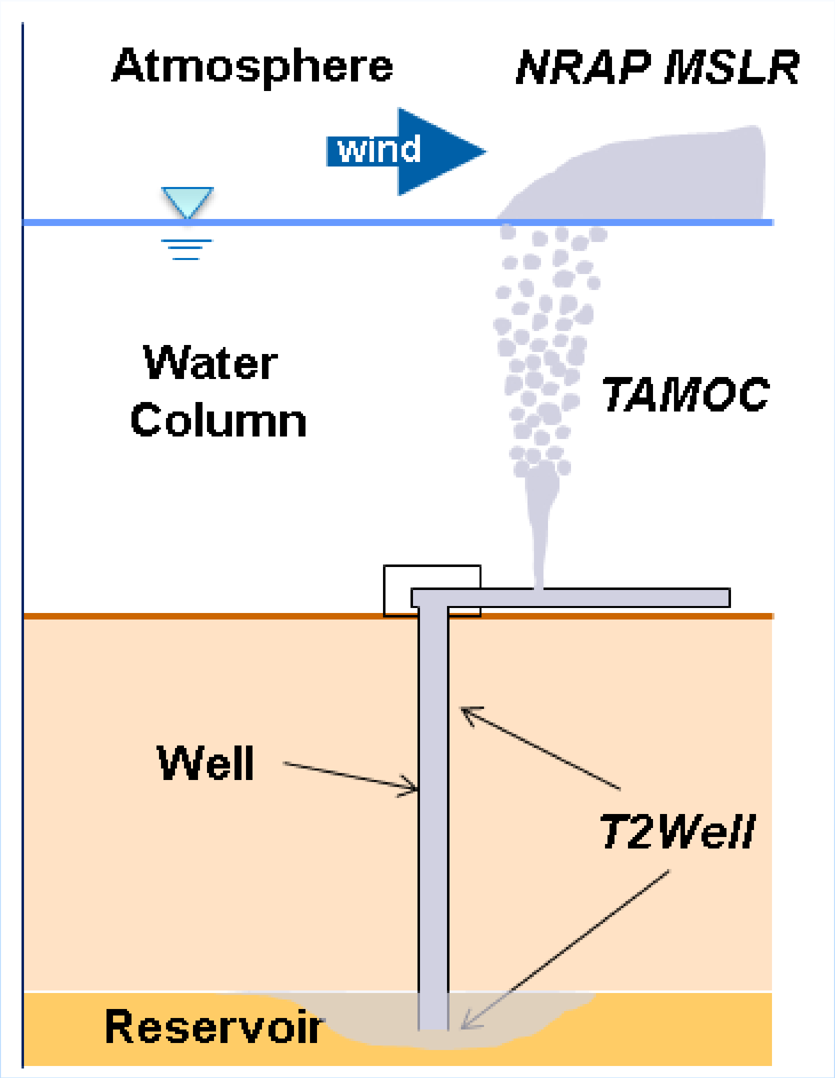
Seawater - CO_2 Dissolution

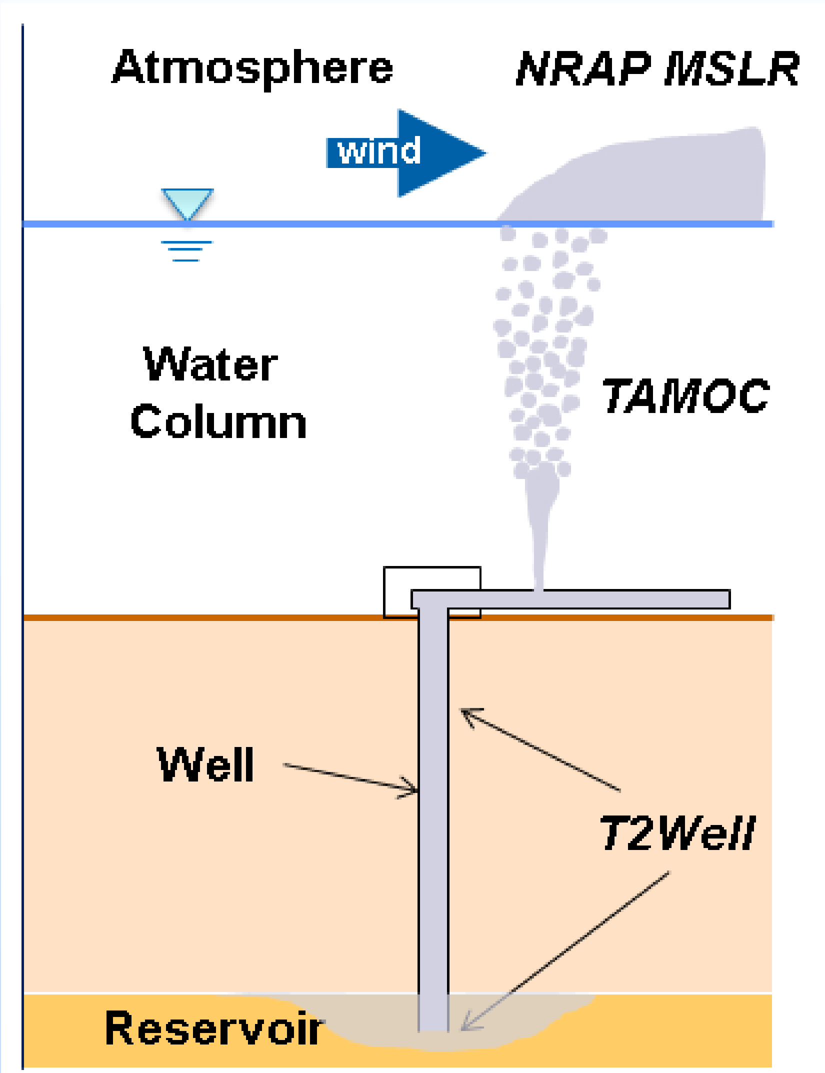


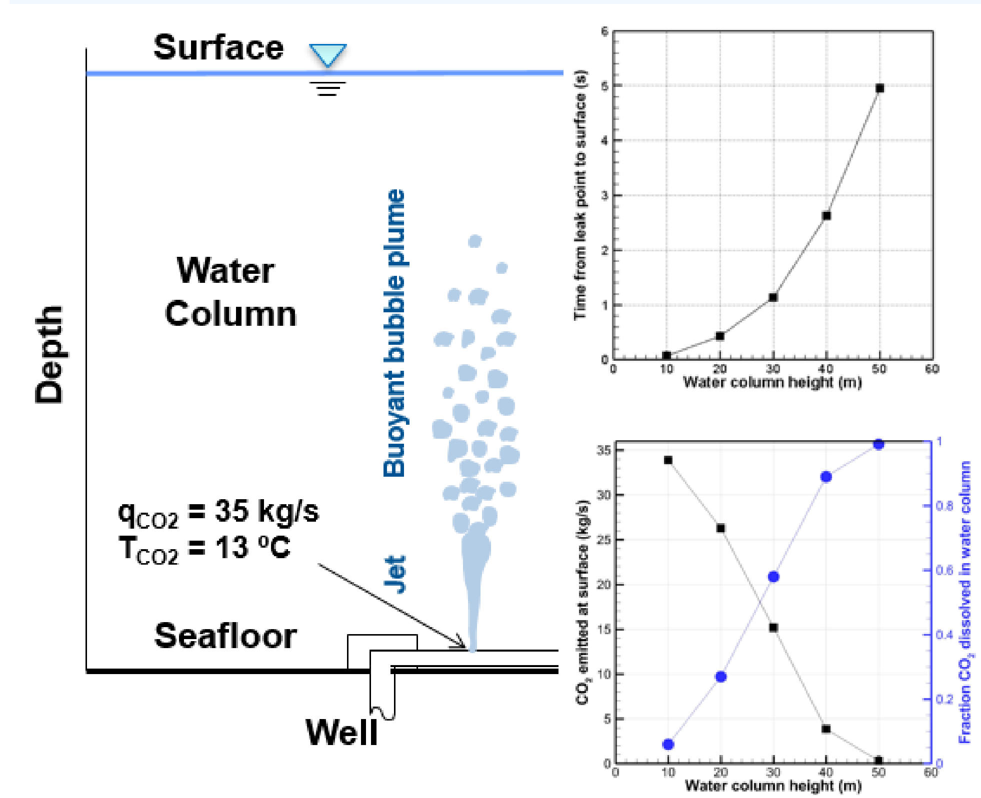
Offshore CO_2 blowouts different from onshore

Strong water column effects

Curt Oldenburg, Lehua Pan and Yingqi Zhang

Seawater - CO_2 Dissolution

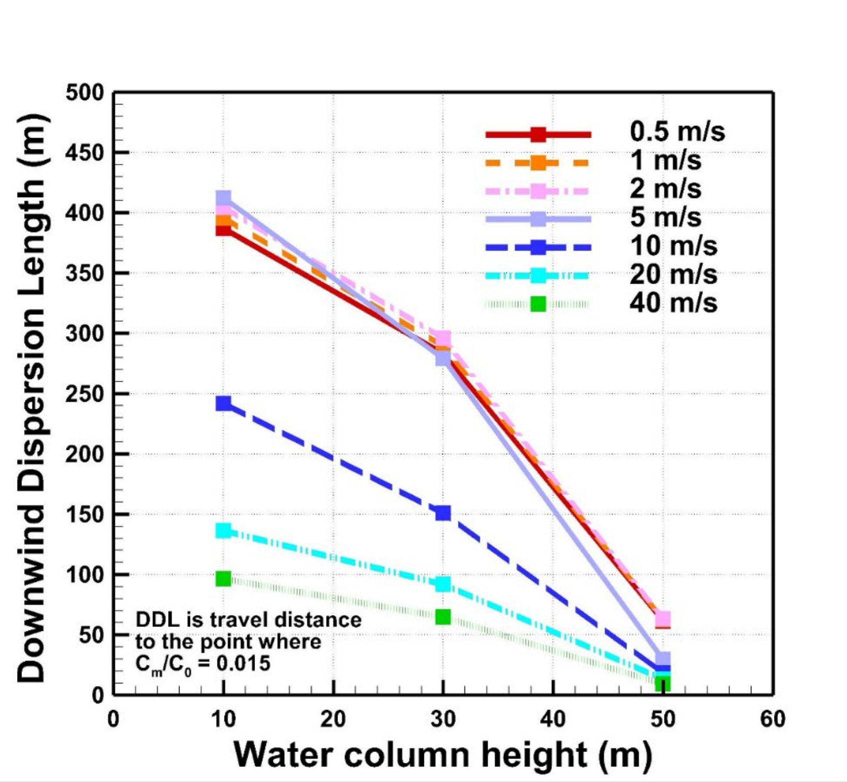




Curt Oldenburg, Lehua Pan and Yingqi Zhang

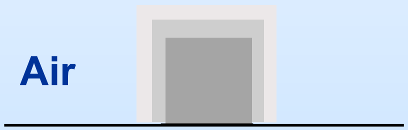
Results: Downwind Dispersion Length (DDL) varies with depth and windspeed

- **Source term for the MSLR is the output from TAMOC (i.e., flow rate of CO_2 out of sea surface).**
- **Ran the MSLR for the different water depths and wind speeds.**
- **Results show downwind dispersion length (DDL) is max @ ~400 m (5 m/s; 10 m water depth).**
- **Deeper systems: DDL = 100 m (or less).**



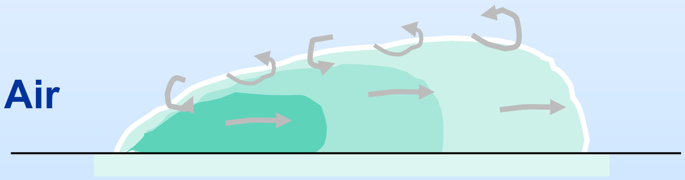
No wind

Gas doesn't move much
= short downwind safety distance



Wind

Gas moves but *disperses*
safety distance longer up to a point …
Higher wind = shorter



Why the reversal in trend at low windspeed?

Tradeoff between wind transporting CO_2 & wind dispersing/diluting CO_2

Results

CO_2 leakage strongly controlled by dissolution water column

- **Above sea surface, plume dispersed by dense gas flow & wind**
- **Downwind Dispersion Length (~*radius of safety exclusion zone*)**

1. **Several 100s meters shallow-water**
2. **Deep-water = less DDL**

For more details

Oldenburg, C.M. and Pan, L., 2020. Major CO_2 blowouts from offshore wells are strongly attenuated in water deeper than 50 m. *Greenhouse Gases: Science and Technology*, *10*(1), pp.15-31. https://doi.org/10.1002/ghg.1943

Oldenburg, C.M. and Zhang, Y., 2022. Downwind dispersion of CO_2 from a major subsea blowout in shallow offshore waters. *Greenhouse Gases: Science and Technology, 12(2), pp. 321–331*. https://doi.org/10.1002/ghg.2144

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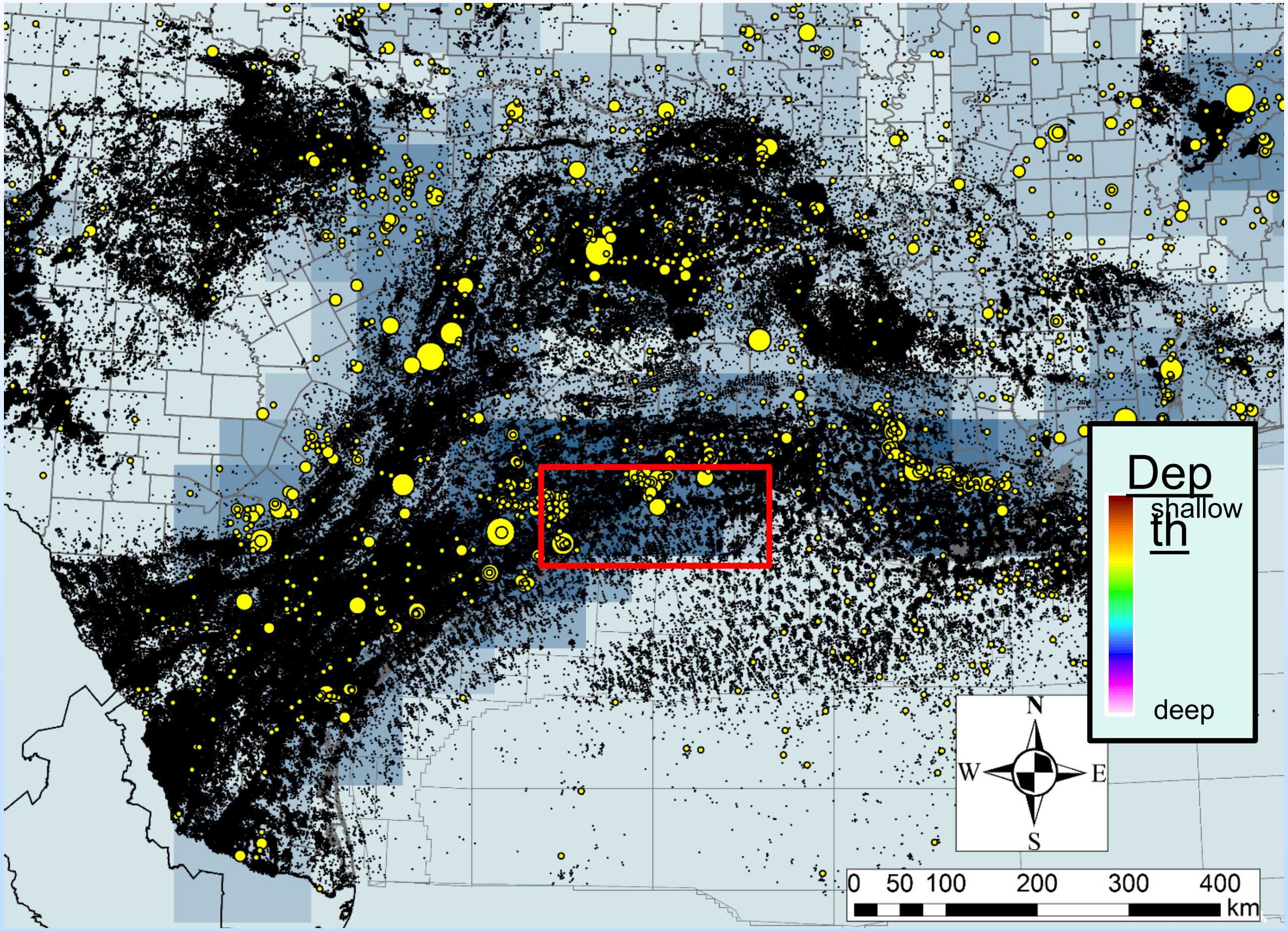
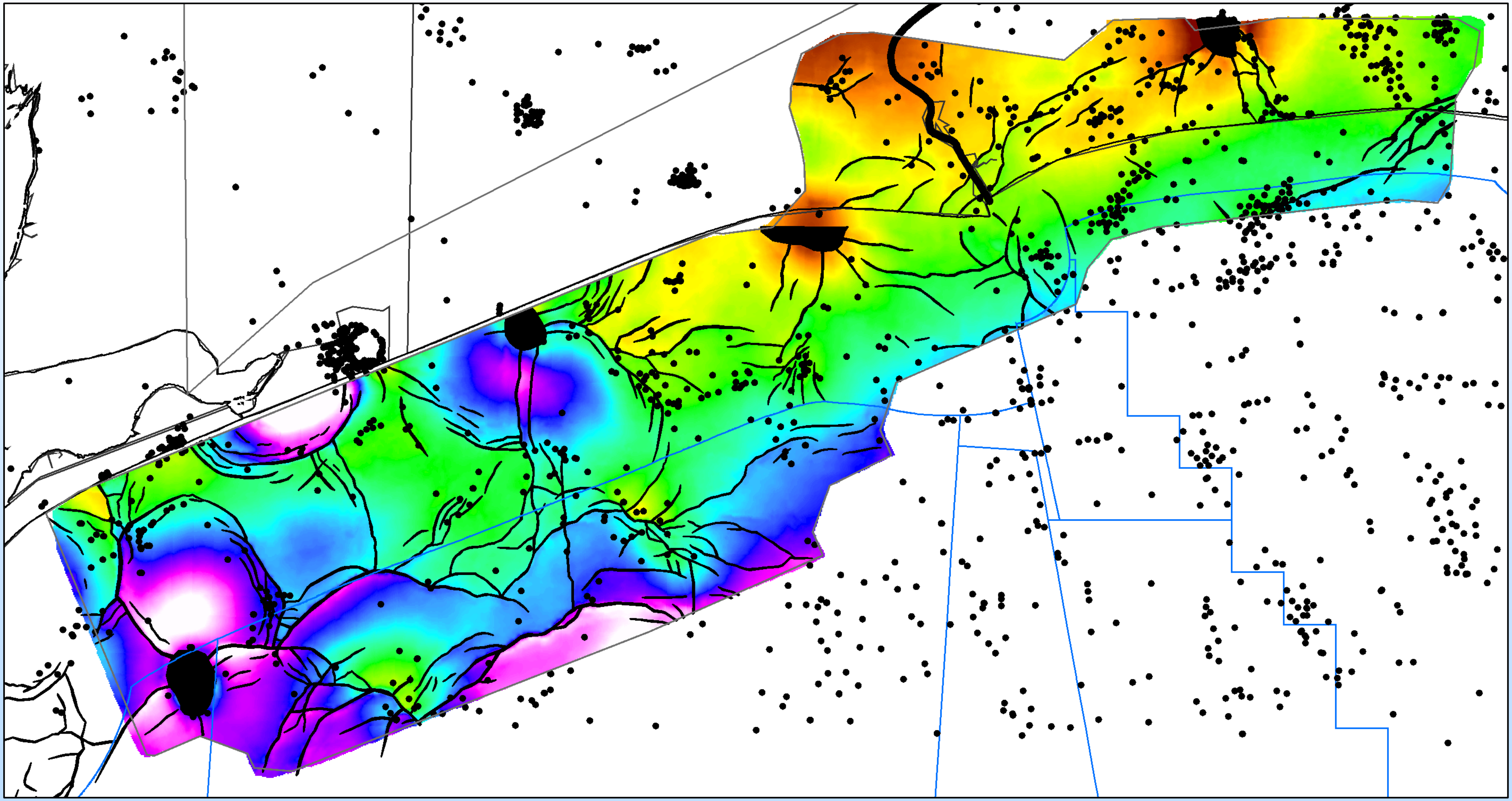
Wells Targeting Miocene Reservoirs



Alex Bump, Gillian Apps, Frank Peel

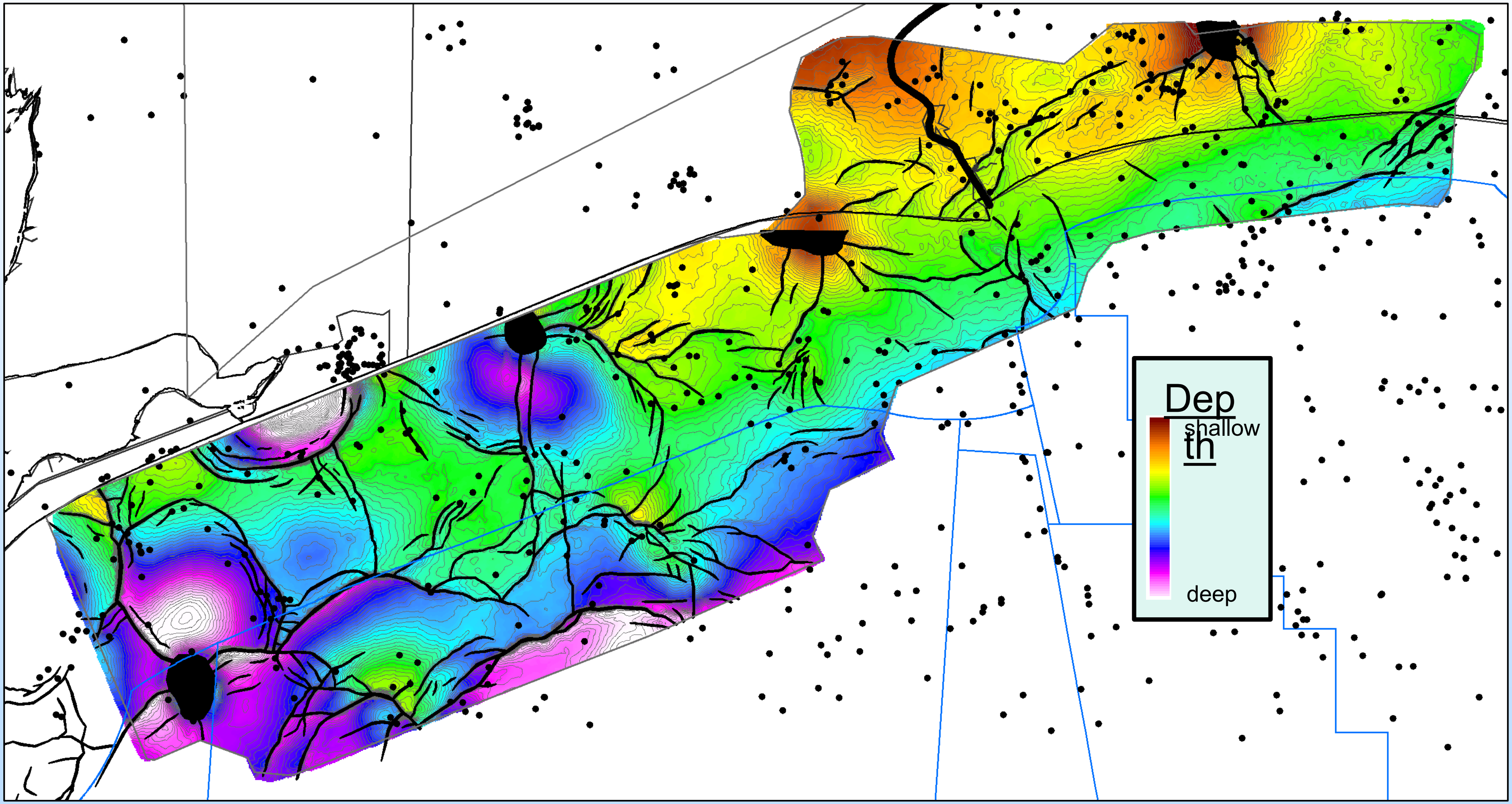
Wells Targeting Miocene Reservoirs



Alex Bump, Gillian Apps, Frank Peel

Seismic interpretation courtesy of **Mike DeAngelo**; Well data: **IHS Enerdeq**, 2022

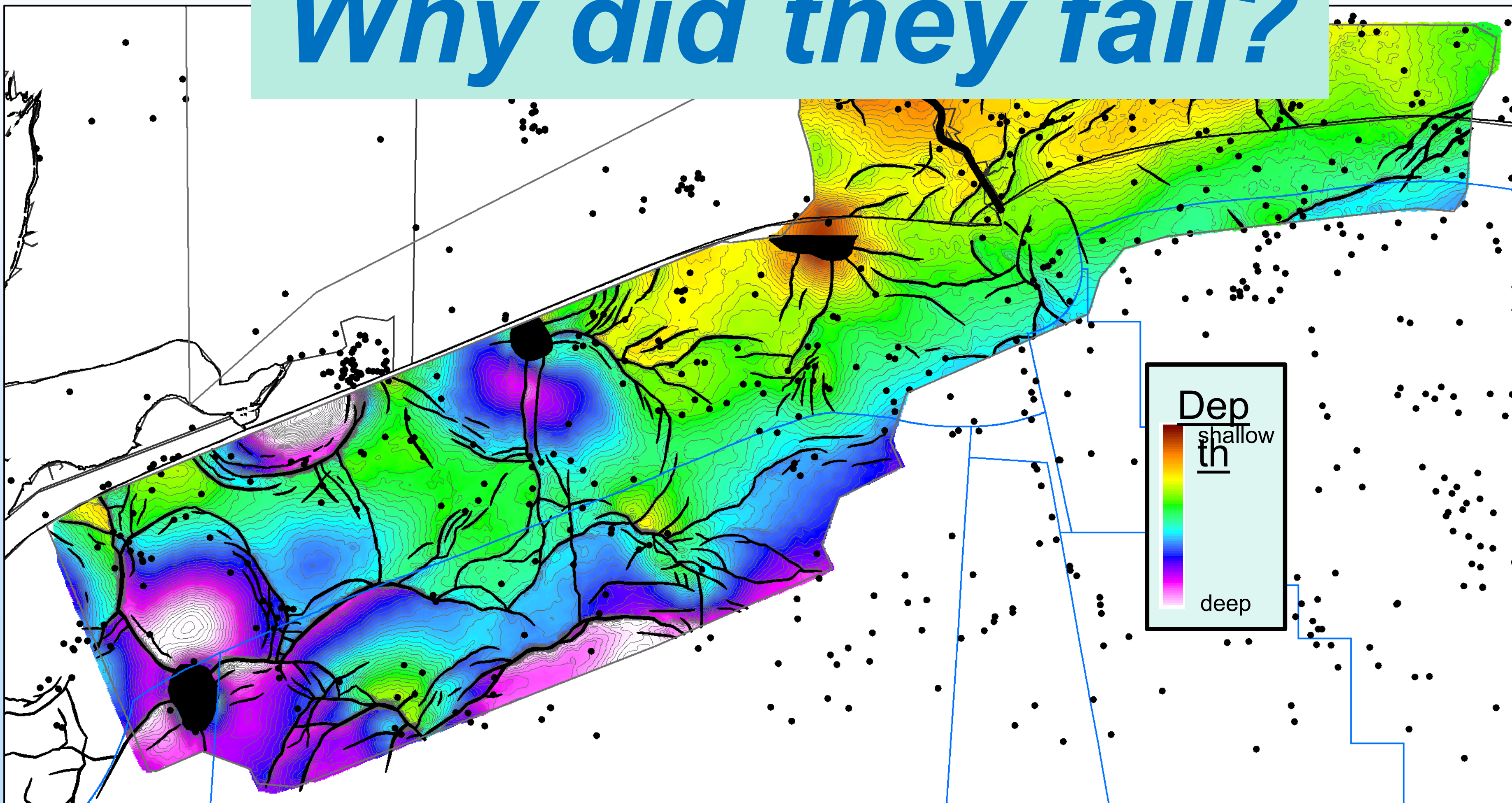
Miocene Dry Holes



Seismic interpretation courtesy of Mike DeAngelo; Well data: IHS Enerdeq, 2022

Miocene Dry Holes

Why did they fail?

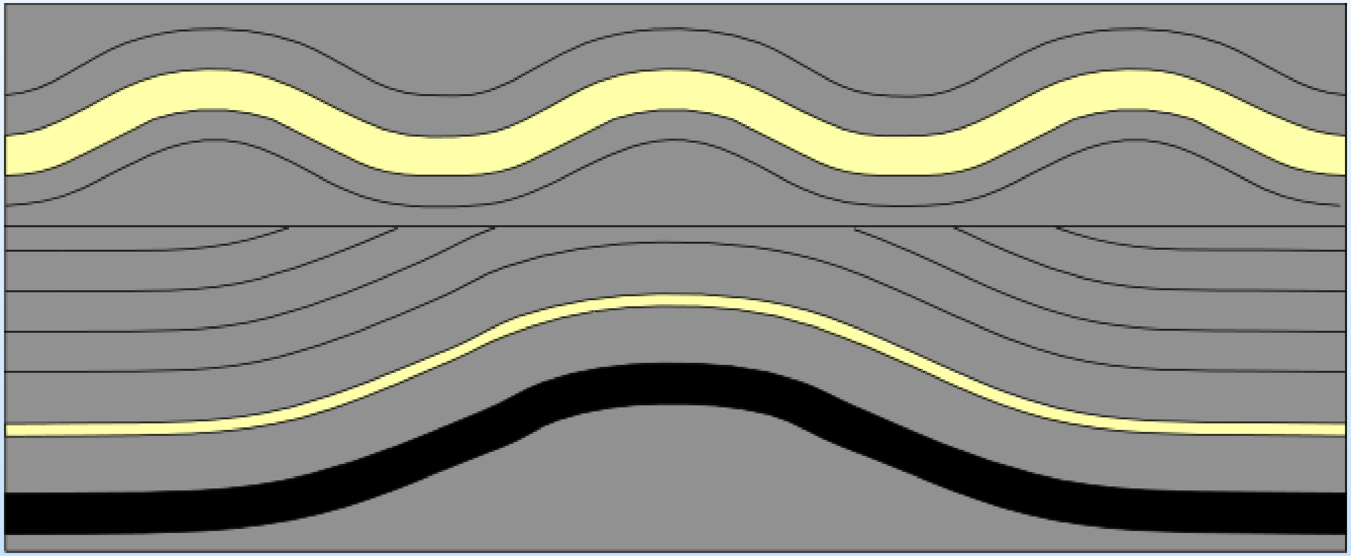


Seismic interpretation courtesy of Mike DeAngelo; Well data: IHS Enerdeq, 2022

Upper TX / Western LA Coast

Hydrocarbon Exploration Successes / Failures

Play
Elements



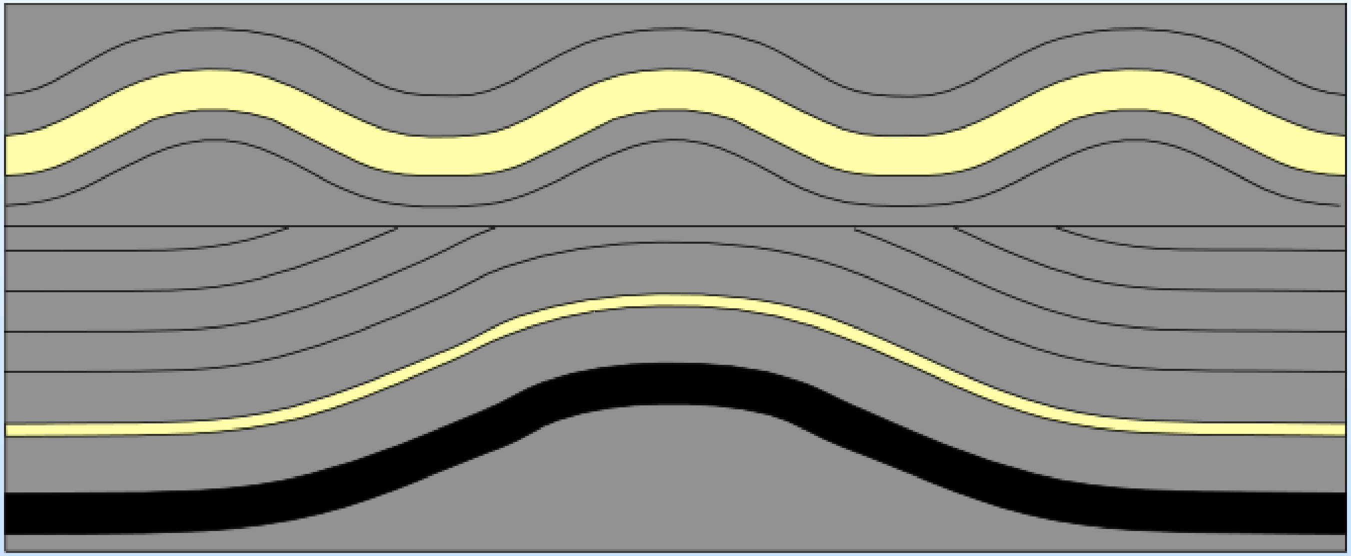
Upper TX / Western LA Coast

Hydrocarbon Exploration Successes / Failures

Play Elements

Charge access
- Thermal maturity
- Migration path

Source



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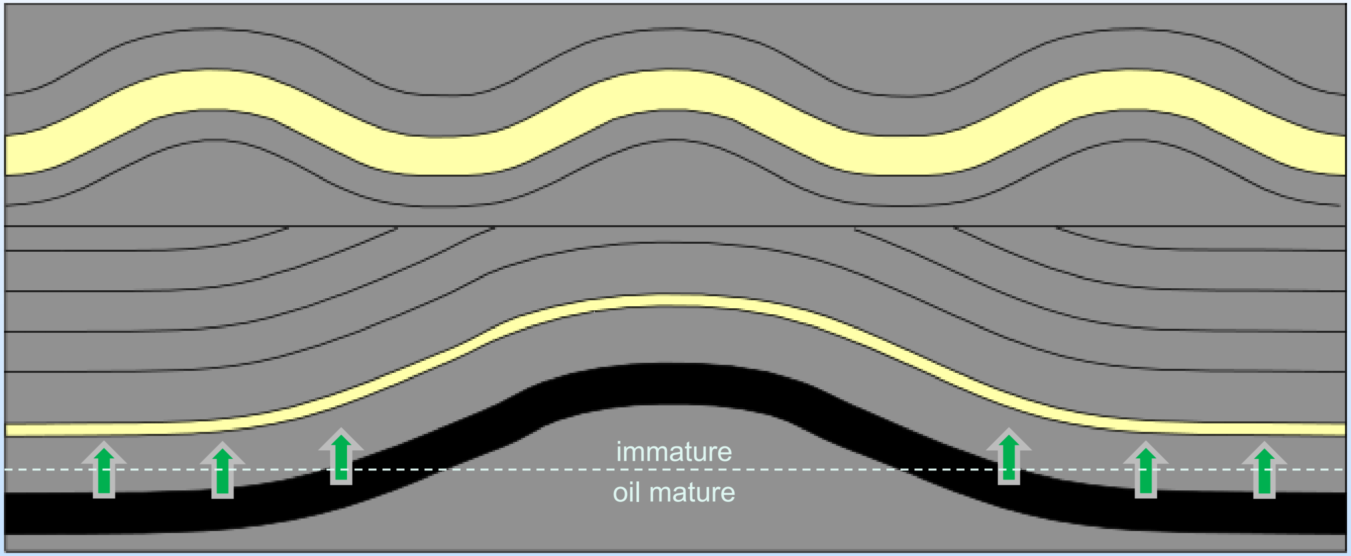

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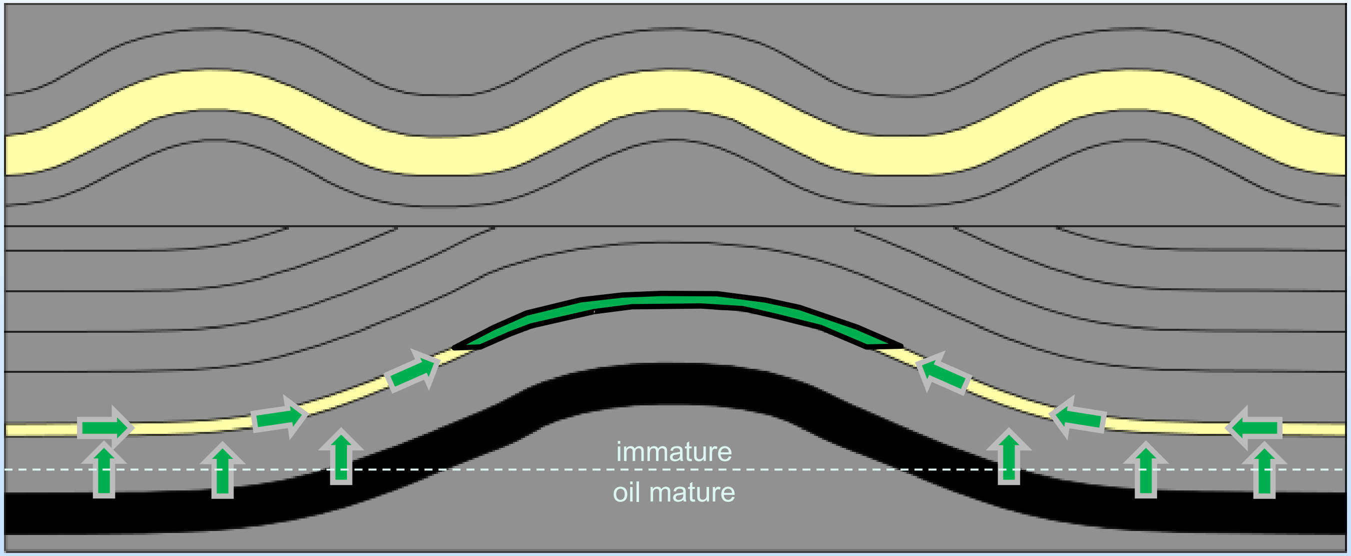

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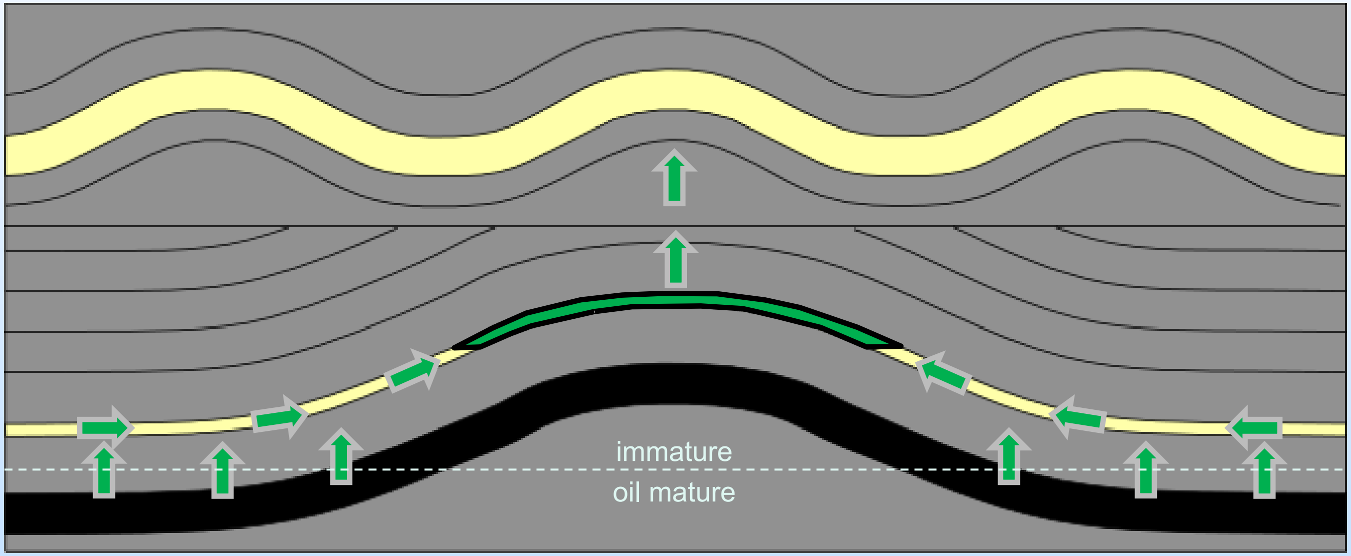

Upper TX / Western LA Coast

Hydrocarbon Exploration Successes / Failures

Play Elements

Reservoir

Charge access
- Thermal maturity
- Migration path

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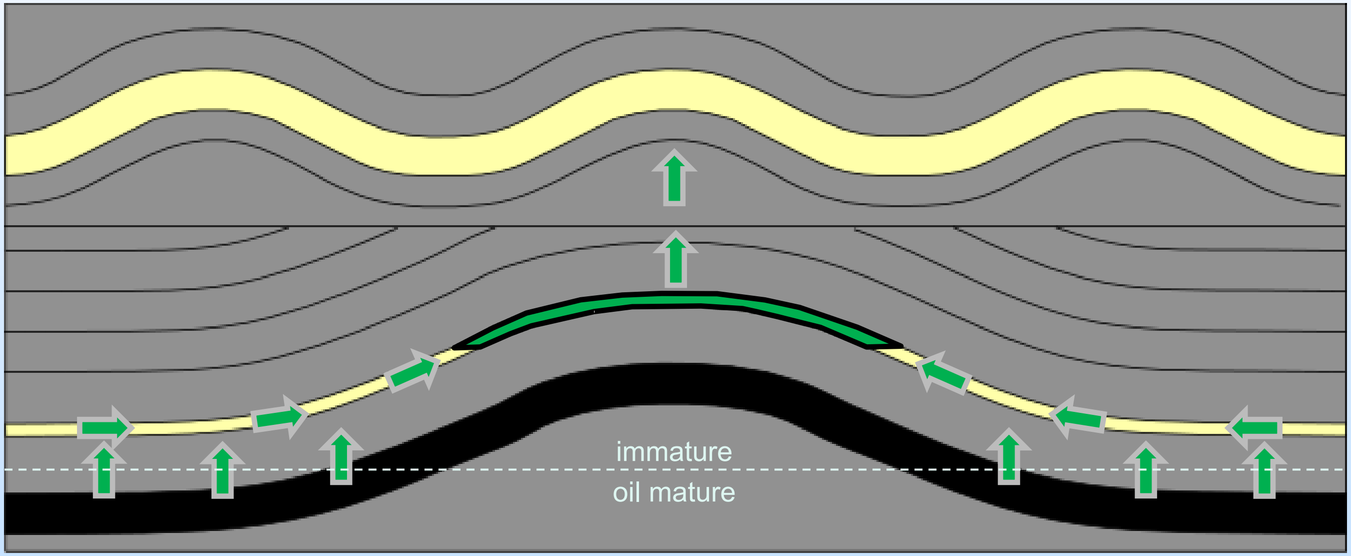


Upper TX / Western LA Coast

Hydrocarbon Exploration Successes / Failures

Play Elements

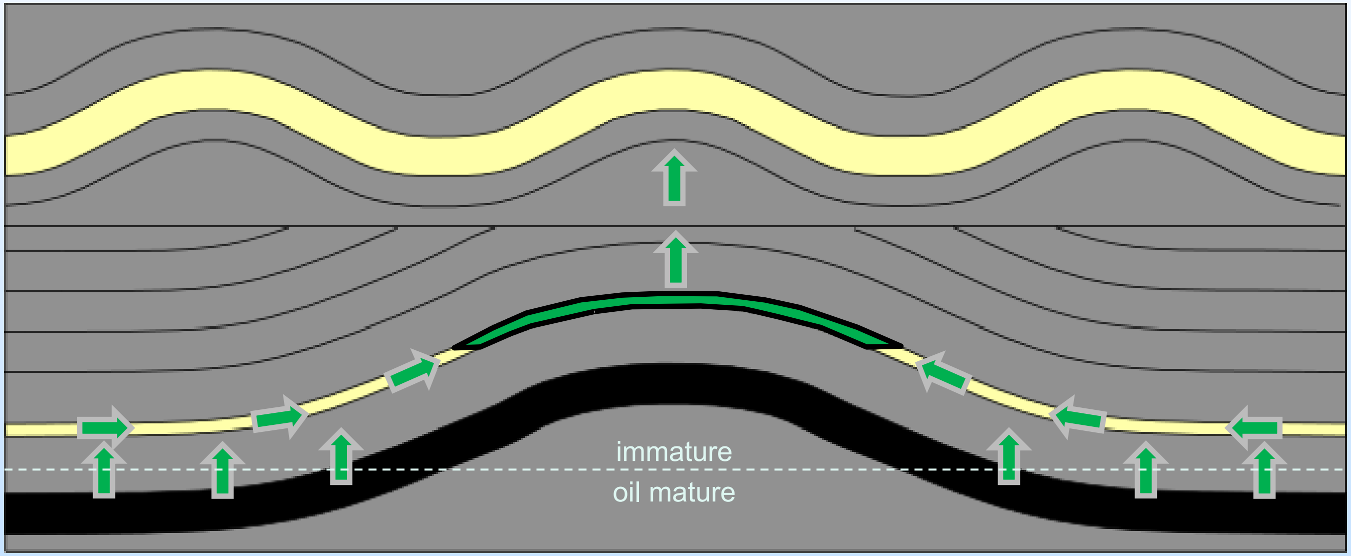
Trap

Reservoir

Charge access

- Thermal maturity
- Migration path

Source



Upper TX / Western LA Coast

Hydrocarbon Exploration Successes / Failures

Play Elements

Confining Zone (Seal)

Trap

Reservoir

Charge access
- Thermal maturity
- Migration path

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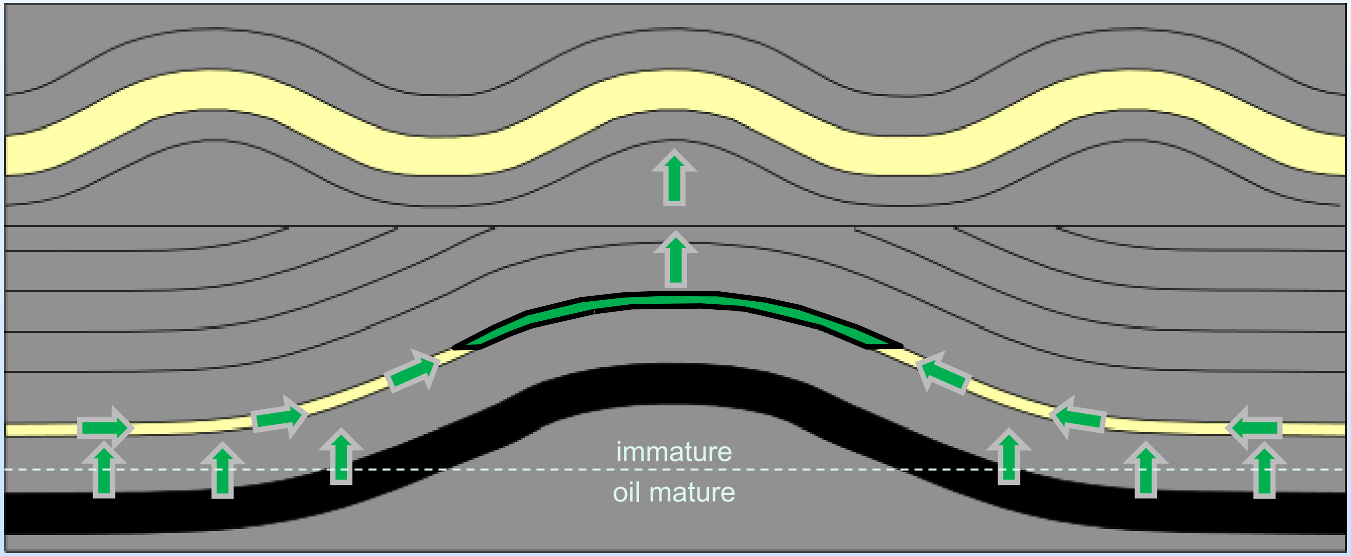

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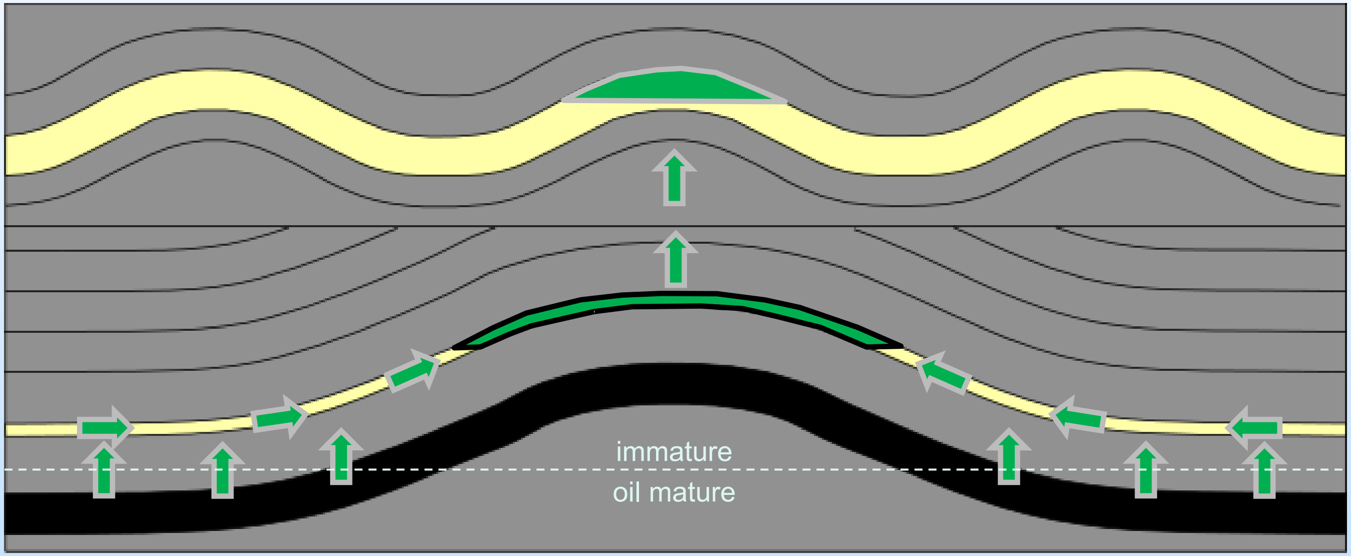

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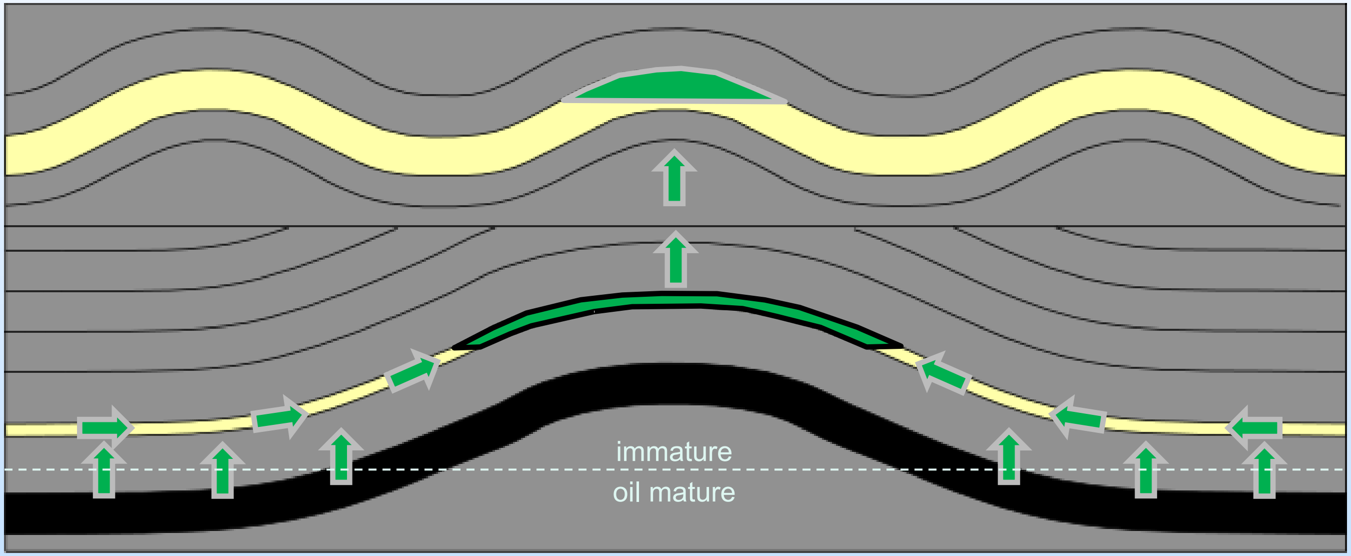

All elements need to work to create a producible hydrocarbon accumulation

Early (Oligocene) thrusted terrane cut by later (Miocene) extension

Play Elements

Confining Zone (Seal)

Trap

Reservoir

Charge access

- Thermal maturity
- Migration path

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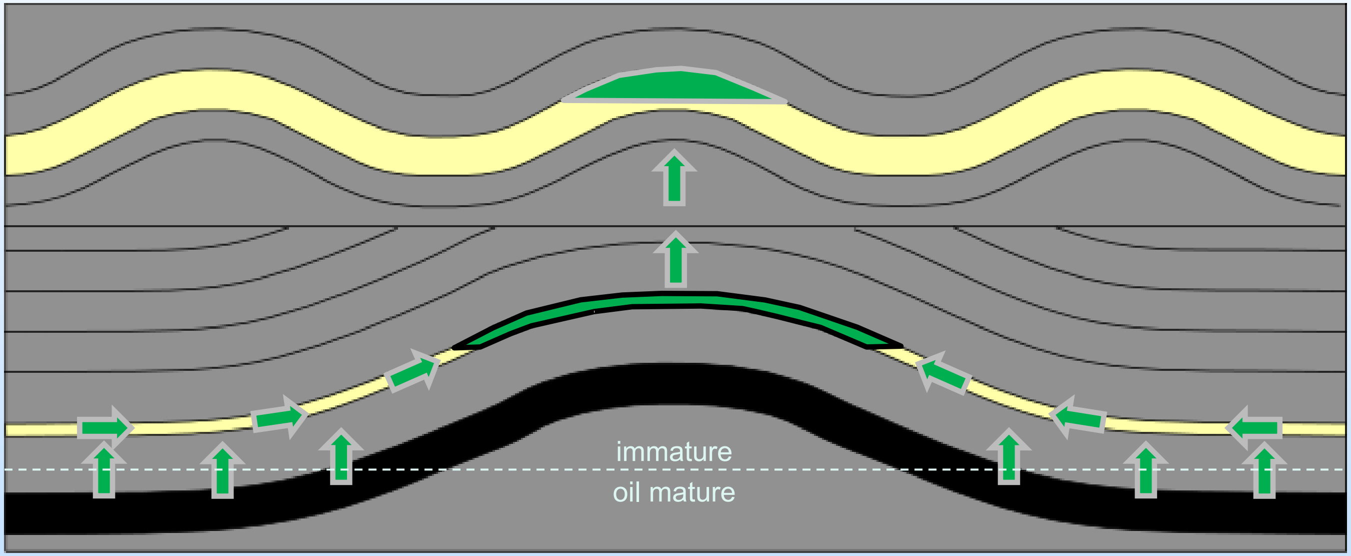

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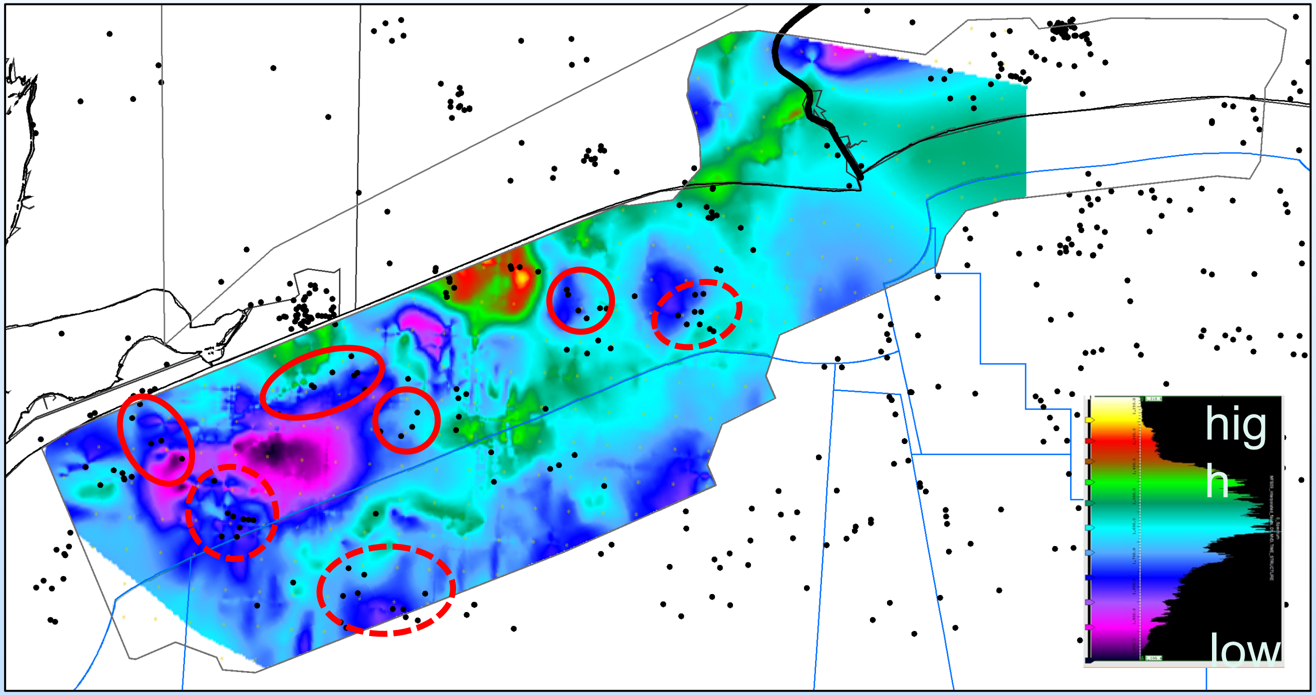
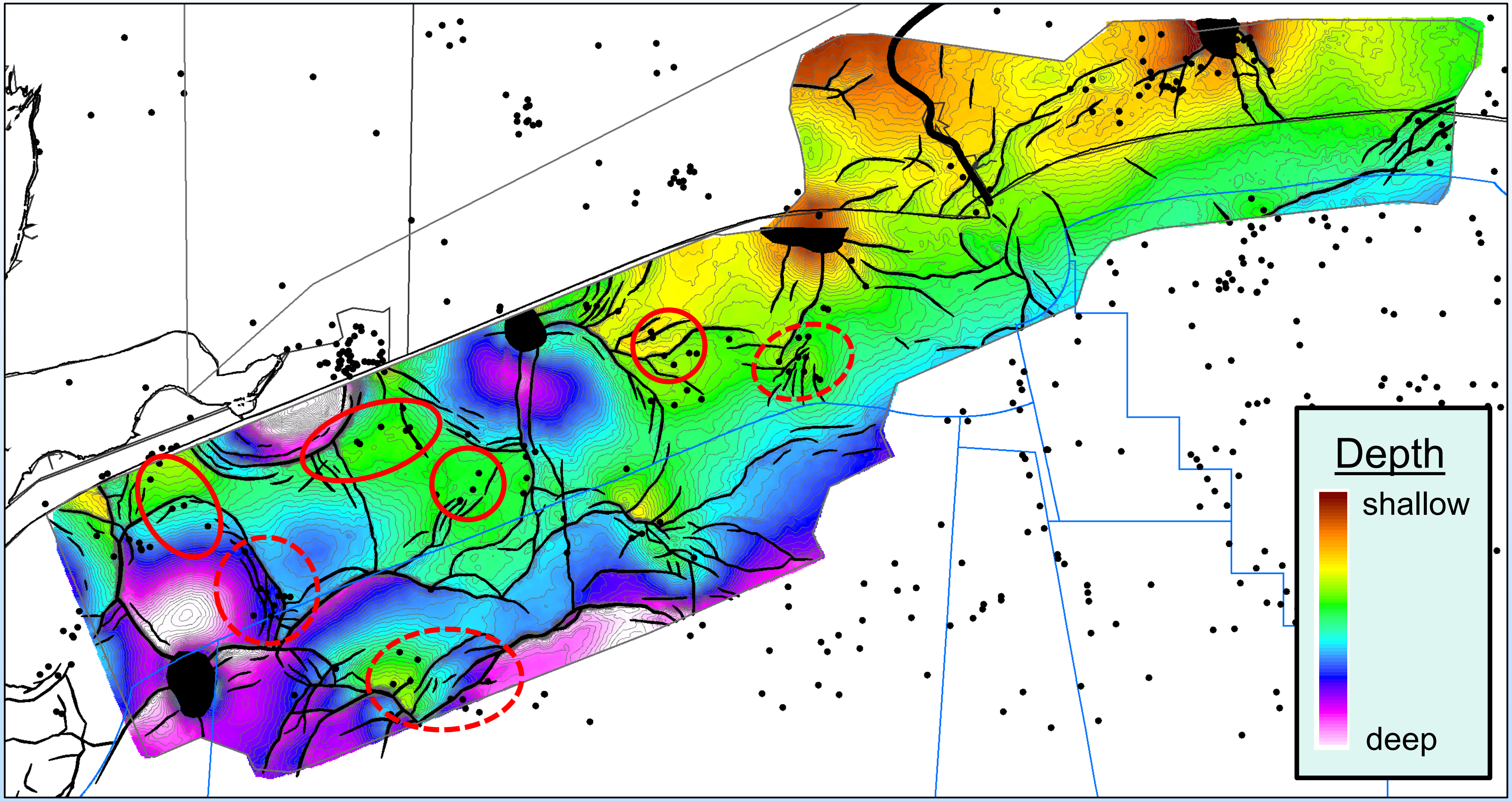
Oligocene Focus
Miocene dry holes



Circles show
defocused charge

Well data: IHS Enerdeq, 2022

Dry Holes w/Valid Trap but No Charge Focus



Implications for seal risk

For the upper Texas Coast, we can show that most of the dry holes resulted from either:

- no valid trap
- no charge

For the remaining dry holes, the locations of adjacent production wells suggest failure from either:

- missing channelized reservoirs
- drilling down-dip of a small column, most likely limited by fault seal

Elimination of the Bayesian inference (a.k.a. *update*) allows us to discount the dry holes in our assessment of top seal for CCS

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Texas state waters infrastructure re-use

- <u>Pipelines</u>:
  - **<u>Scale</u>** of pipeline re-use opportunity limited by size and pressure rating
  - Re-use vs. new is not binary
    - <u>Incremental Capacity</u>: Pair existing with new (reduce total investment)
    - <u>"Phased" Investment:</u> Start-up with existing, build-out new (flexibility)
  - Existing right-of-way, existing routes have inherent value
- <u>Wells</u>:
  - Quality of records and condition of wells represent a <u>risk</u> to CCS projects
  - Opportunities for re-use will be case specific, risk for leakage will be general
- <u>Platforms</u>:
  - Limited stock of "newer" platforms
  - Cost to retrofit vs. new platform is case-specific
- Engineering studies = drive specific decisions on assets
- Decommissioning "best practices" not always followed. Urgency to identify assets before abandonment.

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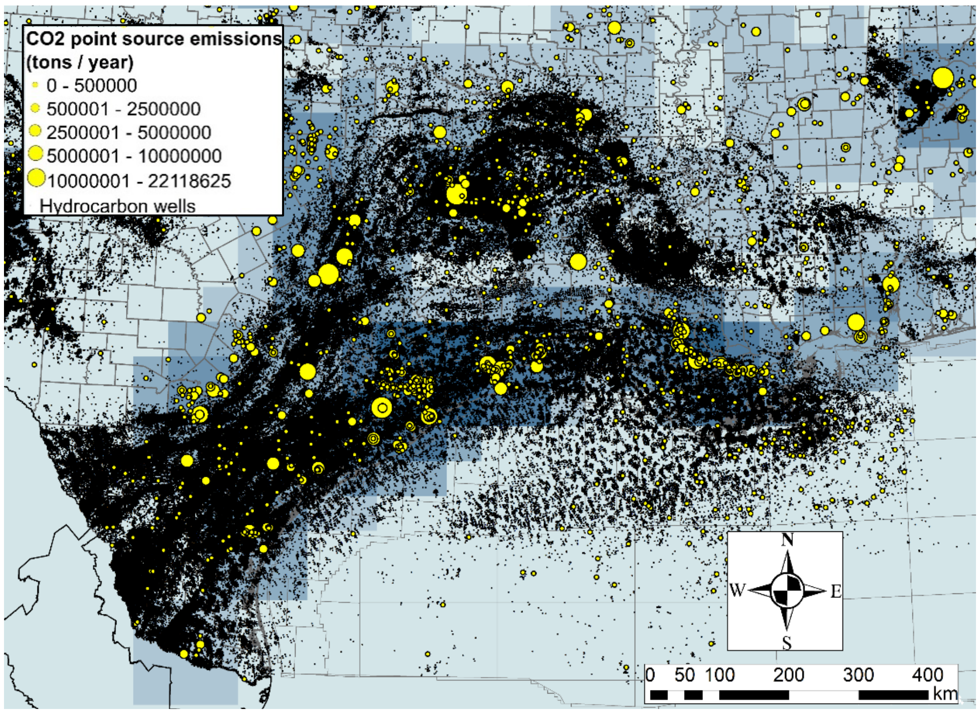
Critical Pressure Analysis Offshore vs. Onshore

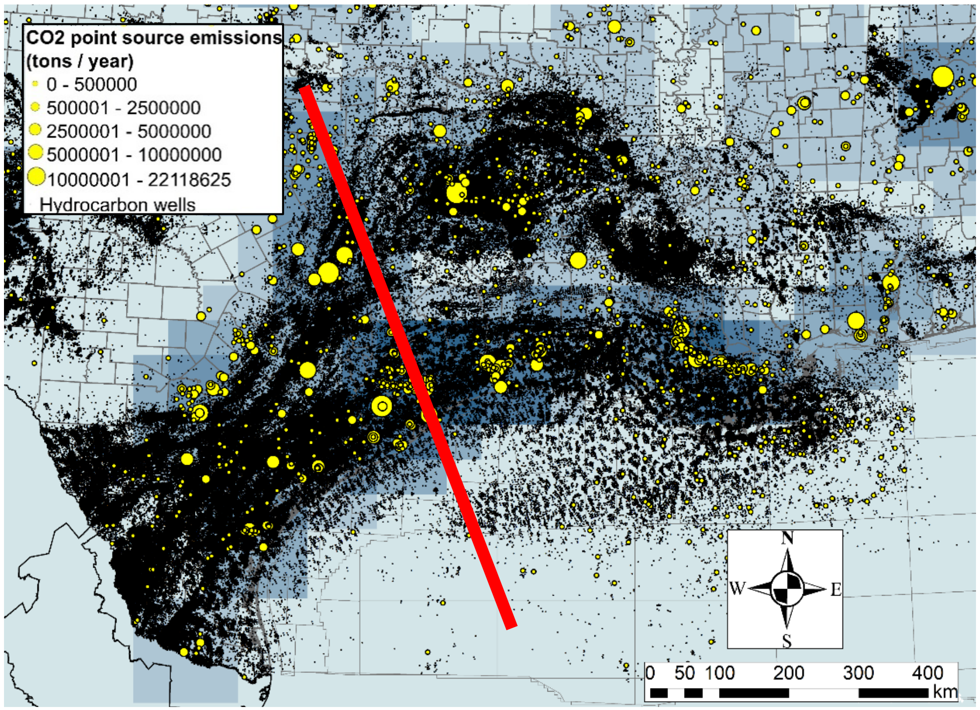


Data: US EPA FLIGHT database and IHS Enerdeq (2022)

- GoM is highly prospective for CO_2 storage
  - Large point-source emissions
  - Abundant subsurface data
  - Proven reservoirs and seals
  - Potentially re-usable infrastructure
- Attraction of offshore
  - Single landowner
  - Relatively few wells
  - Relatively few competing uses
  - Relatively modern infrastructure

Analysis by Alex Bump

Critical Pressure Analysis Offshore vs. Onshore



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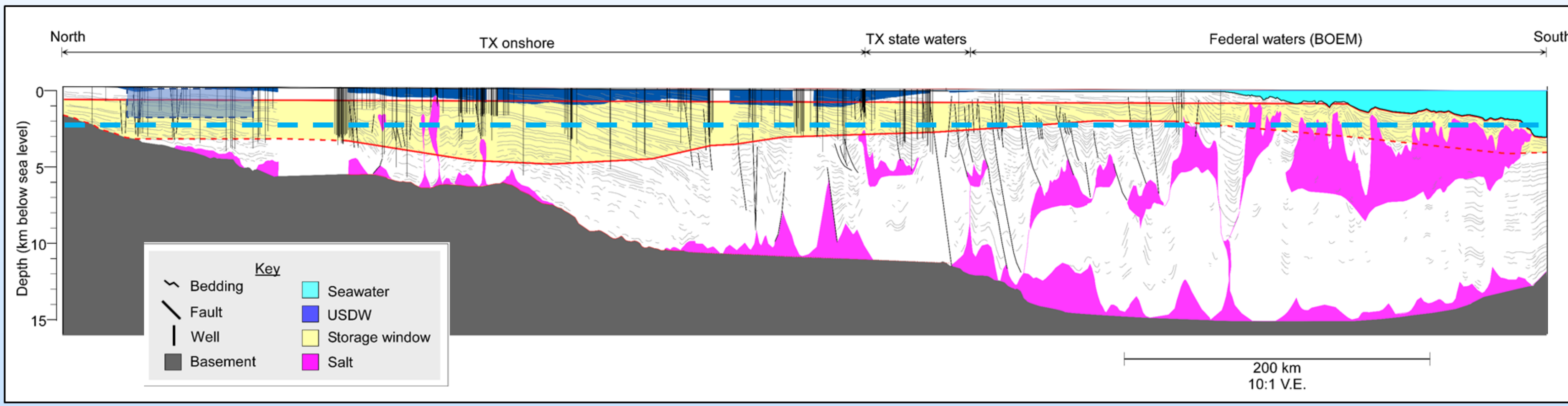
Injection at 2500m Depth

ΔP_{max}	11.9 MPa (Based on San	11.8MPa	11.6 MPa	11.3 Mpa (OP)	6.4 MPa
ΔP_{crit}	0.12 MPa Antonio line)	0.81 MPa	0.89 MPa	0.80 Mpa (OP)	0.26 MPa



All cases: Injection at 2500m depth into brine with 60Kppm TDS; USDW = 6Kppm TDS; Seawater = 35Kppm TDS

ΔP max = pressure increase amount before frac pressure reached (># = larger capacity)

- depth below top key horizons: 1) top of rock col and 2) top of wtr col.

ΔP crit = pressure increase that defines AOR (># = smaller AOR)

- little variability either end of LoS (deep USDW; deep seawater)

1MPa=145psi

Plans for future testing/development/ commercialization

1. Partnership Plans
   a) Assess OCS Opportunities
   b) GoMCarb learnings heavily used to support multiple, in-progress commercial projects
   c) Will acquire two HR3D seismic surveys
   d) Extend infrastructure analysis

2. Next Phase

3. Scale-up potential

Photo courtesy Tip Meckel

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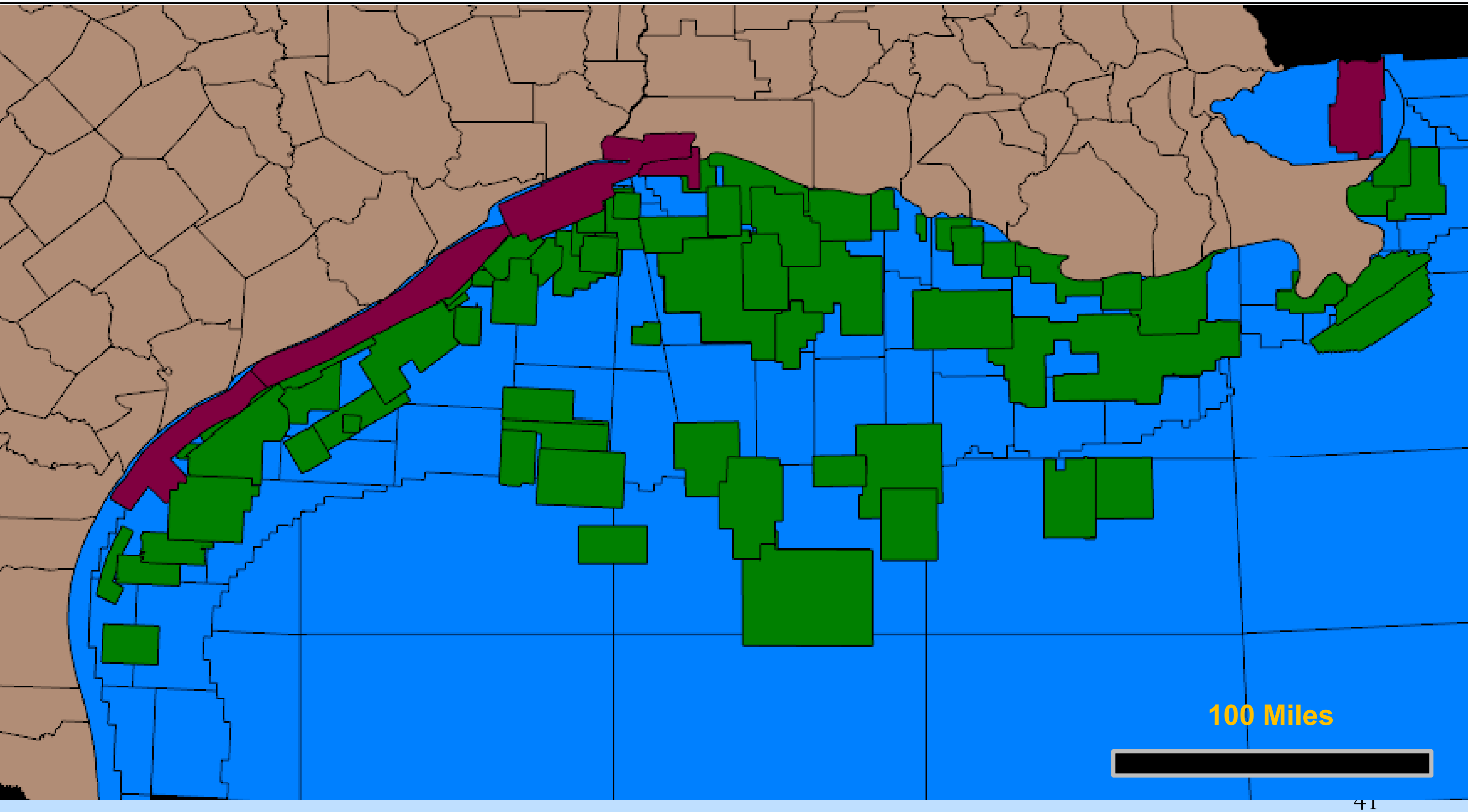
   a) Assess OCS Opportunities

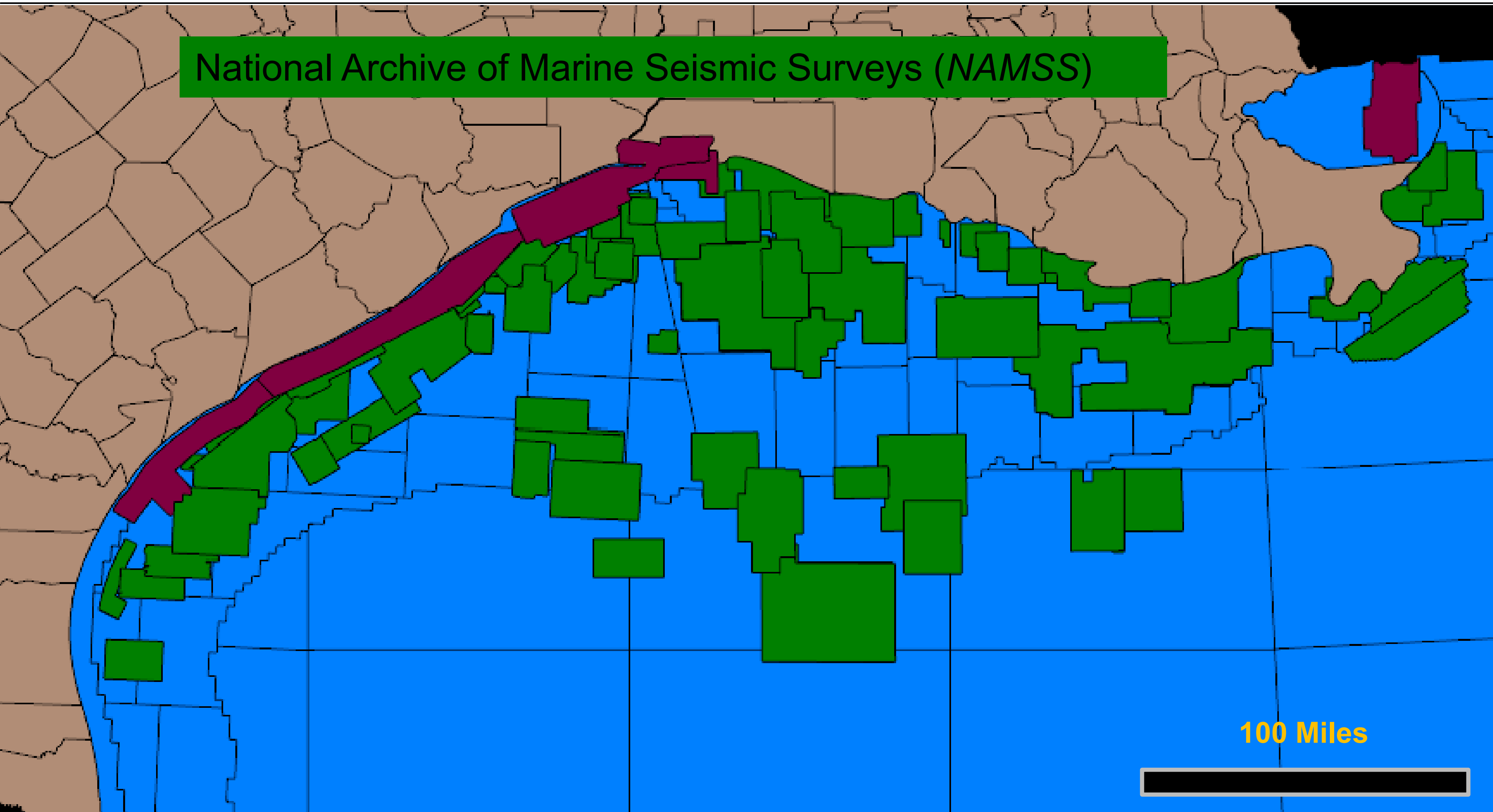
Plans for future testing/development/ commercialization



Publicly available

Leased

Plans for future testing/development/ commercialization



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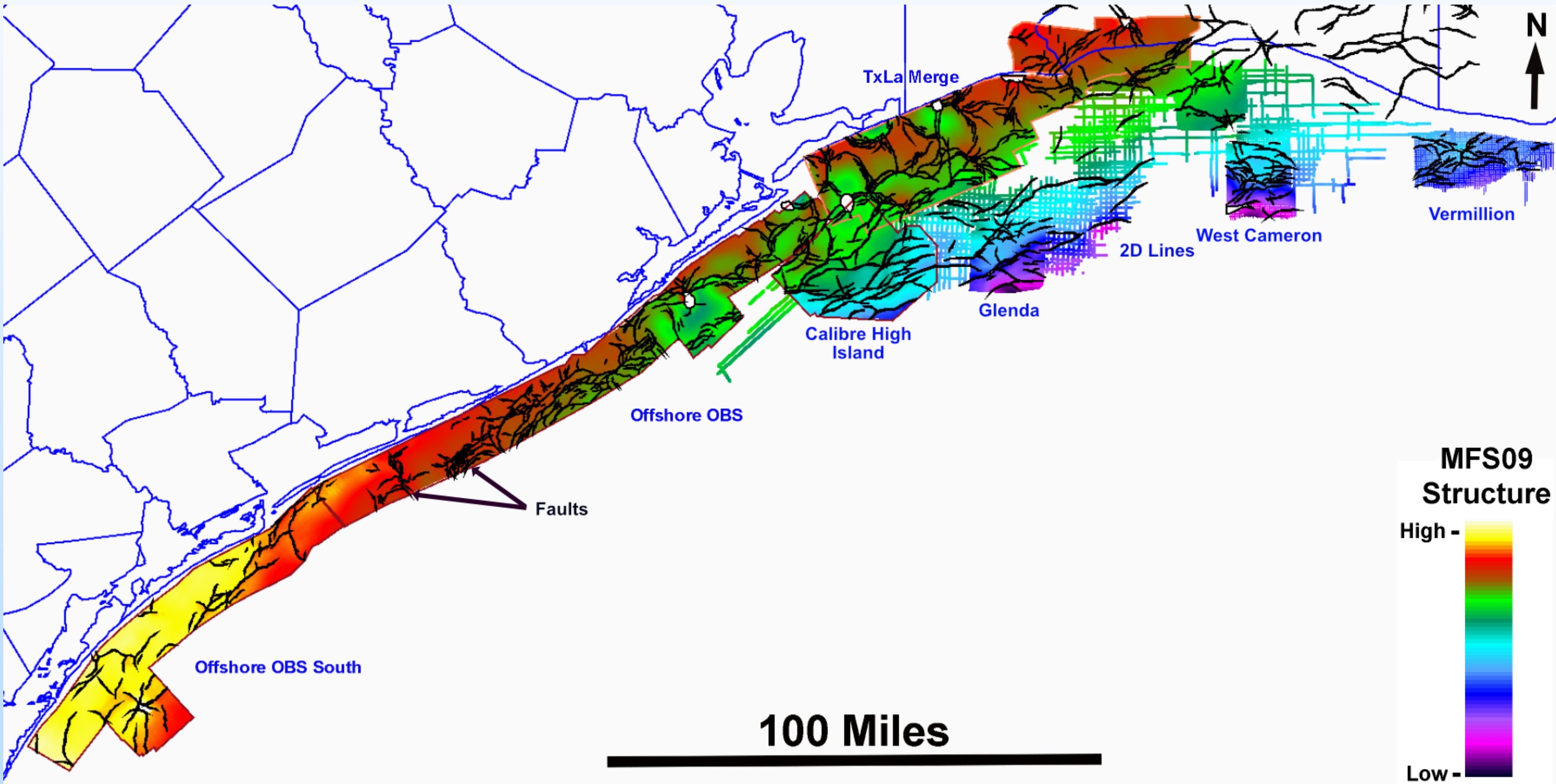
Assessing OCS Opportunities



Plans for future testing/development/ commercialization

1. Partnership Plans
2. Next Phase
    - **a) <u>Collect whole core from Miocene age units</u>.**
    - b) Support developing projects
    - c) Assure containment (faults, dip, penetrations)
    - d) Monitor complex areas with multiple uses (e.g., with wind farms / hydrogen storage)
    - e) Optimize infrastructure (coastal crossings, OCS, compatible uses)
    - f) Monitoring: shallow, microtidal, warm waters of GoM (*not North Sea!*)

Plans for future testing/development/ commercialization

1. Partnership Plans
2. Next Phase
3. Scale-up potential is **HUGE**
   a) XoM announcement – 100 MMT
   b) Talos / CarbonVert / Chevron
   c) Several others (*as yet unannounced*)

Calculating Critical Pressure

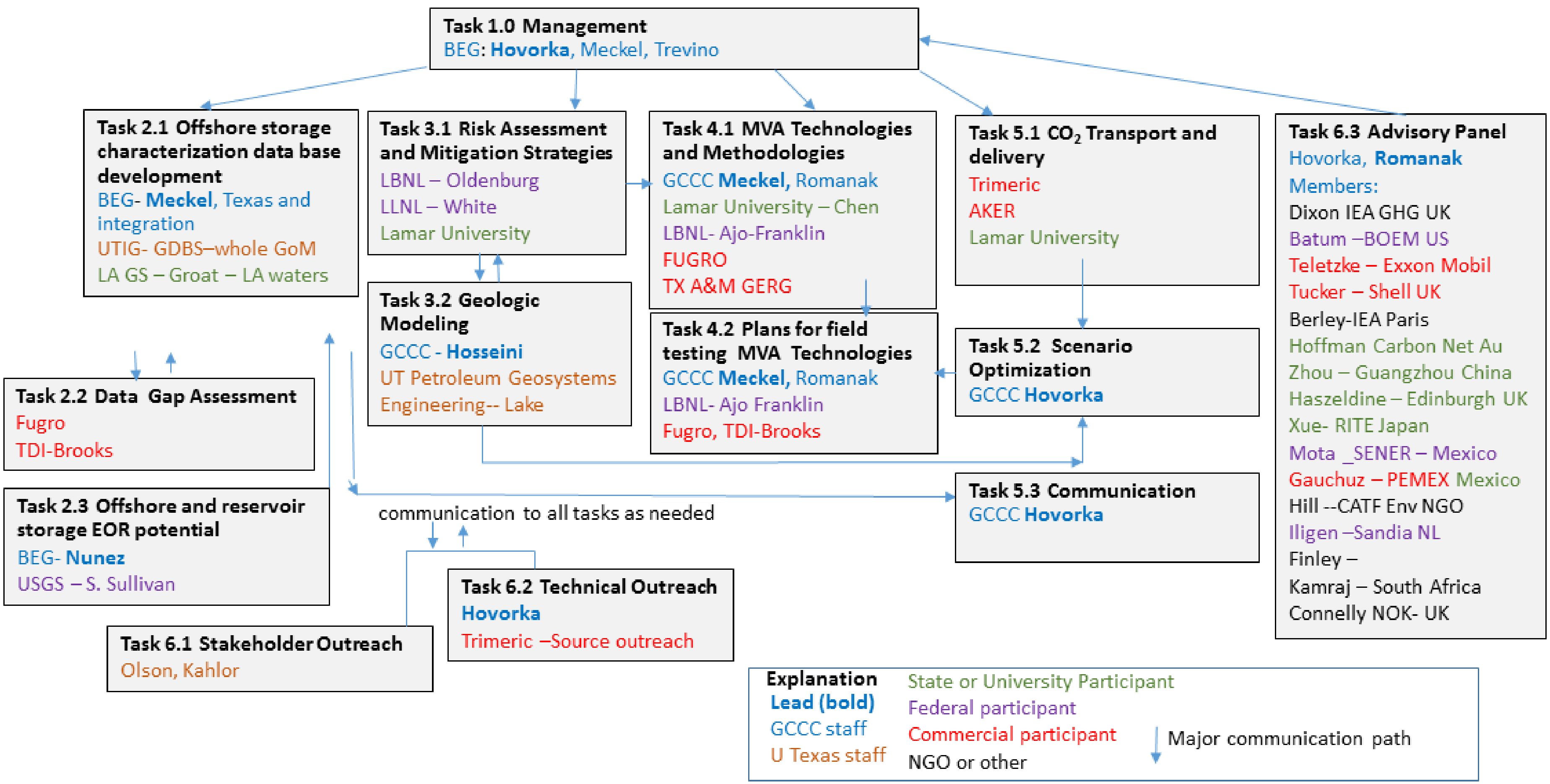
- onshore vs. *offshore*
- Key variables:
  1. Depth below USDW (*mudline?**)
  2. Salinity contrast between injection zone and protected zone (*mudline?**)

**tbd by BSSE*

Appendix

– These slides will not be discussed during the presentation but are mandatory.

Organization Chart



Gantt Chart

Partnership for Offshore Carbon Storage Resources and Technology Development in the Gulf of Mexico		BUDGET PERIOD 1											BUDGET PERIOD 2								
		2018			2019				2020				2021				2022				2023
Task	Tasks	qtr2	qtr3	qtr4	qtr 1	qtr2	qtr3	qtr4	qtr 1	qtr2	qtr3	qtr4	qtr 1	qtr2	qtr3	qtr4	qtr 1	qtr2	qtr3	qtr4	qtr 1
		A-M-J	J-A-S	O-N-D	J-F-M	A-M-J	J-A-S	O-N-D	J-F-M	A-M-J	J-A-S	O-N-D	J-F-M	A-M-J	J-A-S	O-N-D	J-F-M	A-M-J	J-A-S	O-N-D	J-F-M
1	**Project Management, Planning, and Reporting**	**M1**		**M2**																	**M11**
	Revision and Maintenance of Project Management Plan								G-NG												
	Progress Report	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
2	**Offshore Storage Resources Characterization**						**M4**			D2.1a		D2.2a	D2.3a		**M8**						
2.1	Database Development				**M3**																
2.2	Data Gap Assessment																				
2.3	Offshore EOR Potential																				
3	**Risk Assessment, Simulation and Modeling**				3.1a				**M5**		**M6**				D3.2a						
3.1	Risk Assessment and Mitigation Strategies																				
3.2	Geologic Modeling																				
4	**Monitoring, Verification, Accounting (MVA) and Assessment**					D4.1a							**M7**				D4.2a				
4.1	MVA Technologies and Methodologies																				
4.2	Plans for Field Testing of MVA Technologies																				
4.3	Testing MVA Technologies																				
5	**Infrastructure, Operations, and Permitting**						D5.1a						D5.2a							D5.3a	
5.1	CO2 Transport and Delivery																				
5.2	Scenario Optimization																				
5.3	Communication																				
6	**Knowledge Dissemination**			6.1a				6.2a			D6.3a					D6.3b	**M9**		**M10**		
6.1	Stakeholder Outreach																				
6.2	Technical Outreach																				
6.3	Advisory Panel																				

Q = Quarterly Report; A = Annual Report; M = Milestone; DP = Decision Point; D = Deliverable; G-NG = Go/no-go decision point; FR = Final Report