Gulf Coast CCUS

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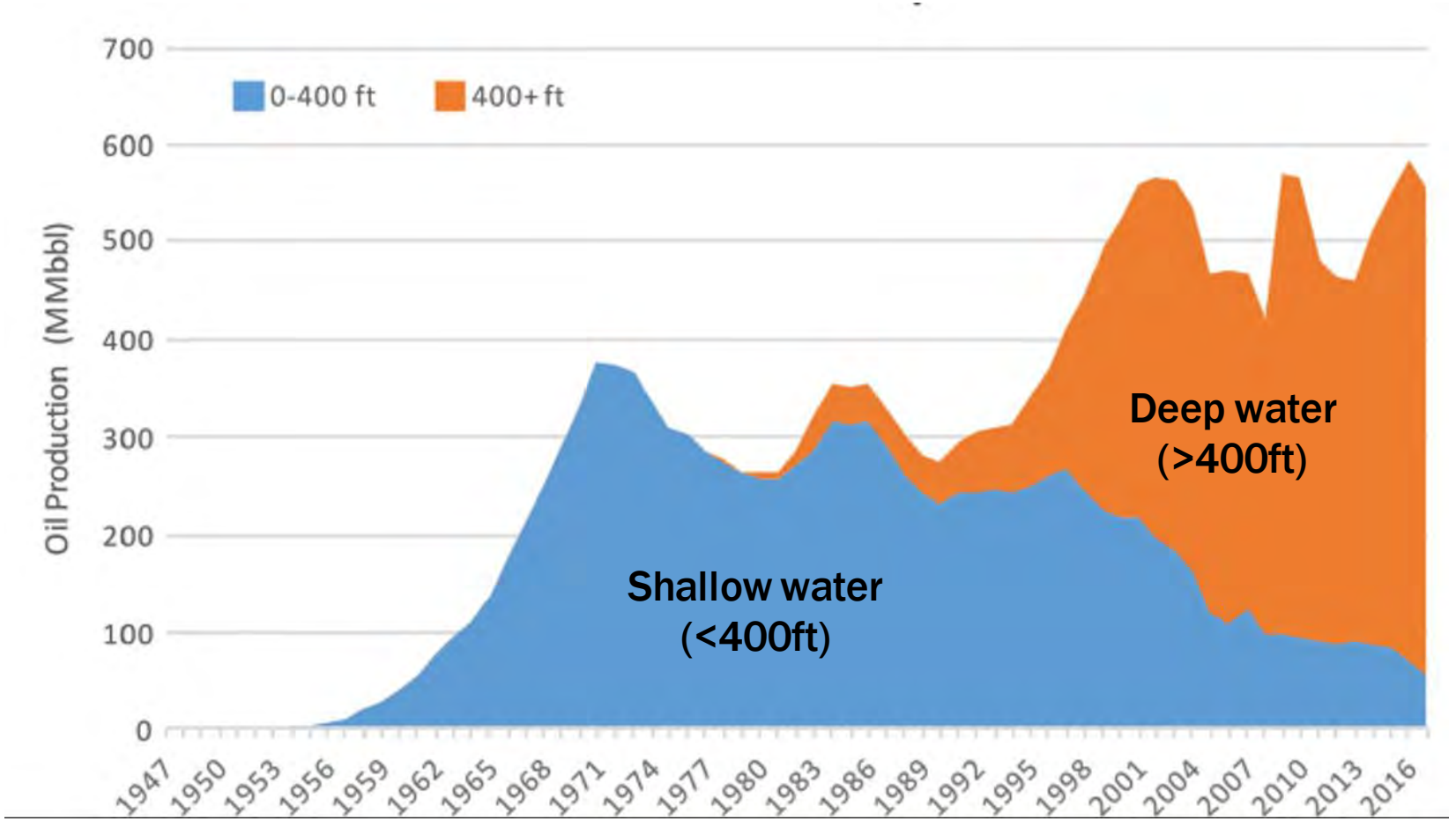
Gulf of Mexico annual oil production



Kaiser and Narra, 2018,

Exploration

GeoExPro, 2018

Too Much of a Good Thing?

JULIANNE GEIGER

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Another Oil Major Sees Peak Oil Demand On The Horizon

By Julianne Geiger - Sep 29, 2020, 5:00 PM CDT

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French energy giant Total SE (formerly Total S.A.) spread more doom and gloom into the oil markets today, foretelling of the oil industry's ultimate horror—peak oil demand.

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The new energy order

Is it the end of the oil age?

What's next?

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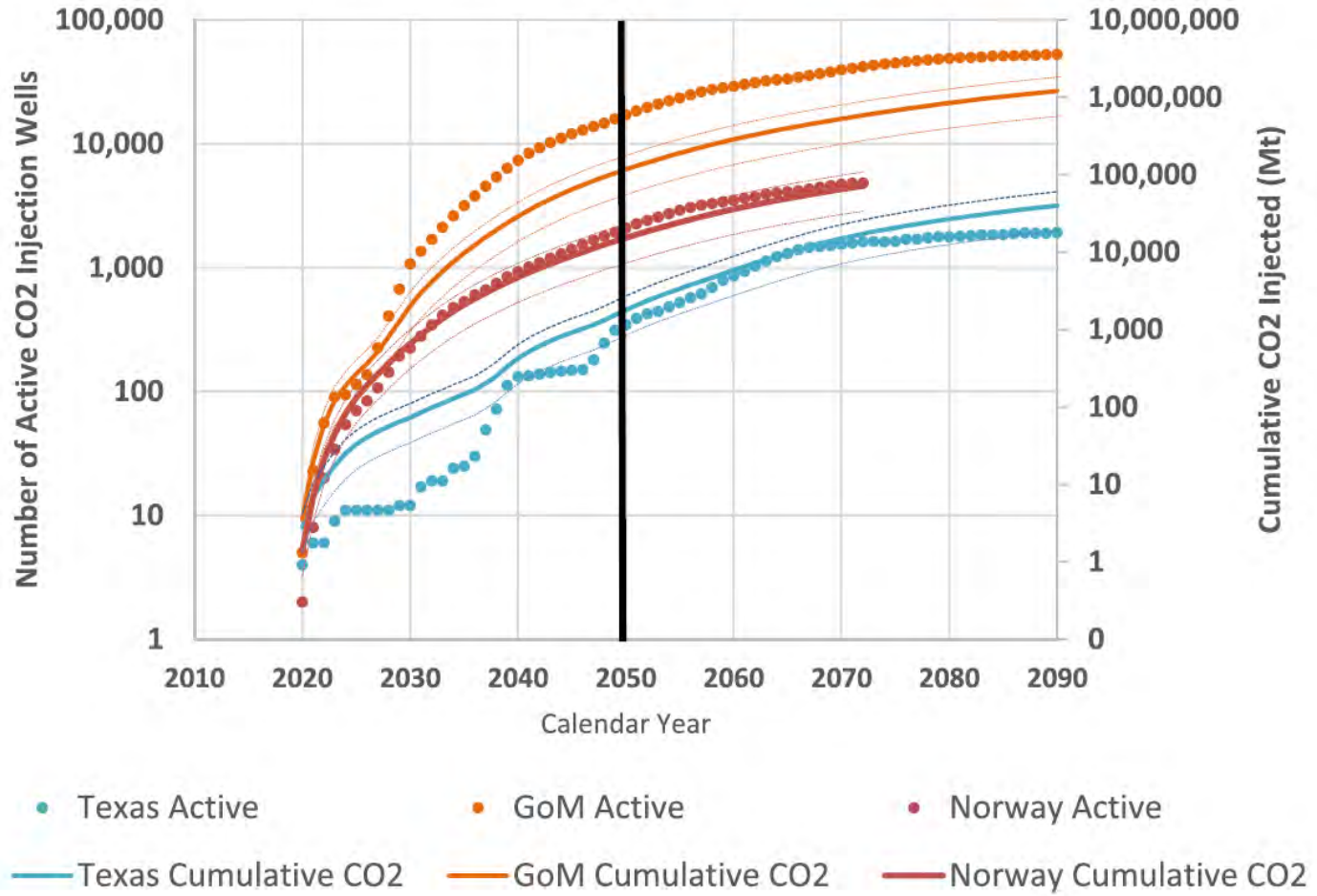
A New Frontier: CCS

Projected growth of storage, based on historical growth of hydrocarbons

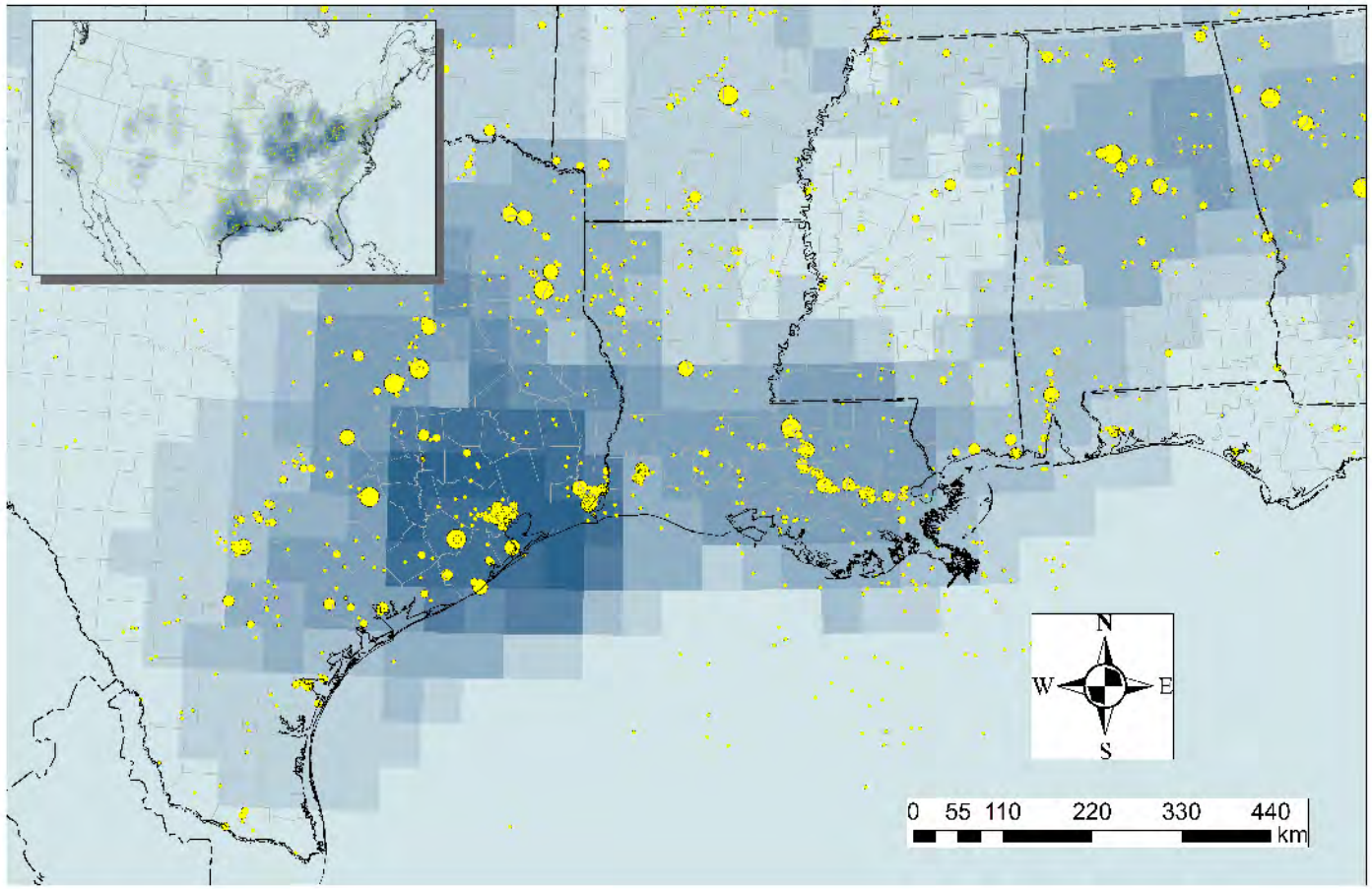


Ringrose and Meckel, 2019

Outline

- 2 questions
  - What is the opportunity?
  - How does it work?
- CO2-EOR
- Storage in depleted fields
- Saline storage
  - Play elements
  - Plays
  - Running room in the GoM
- Conclusion

Source: CO_2 Emissions



Key

- Point source of CO2 emissions (size proportional to yearly emissions volume)
- high / low — Heat map showing total volume of local yearly CO2 emissions

Data: NatCarb, 2019

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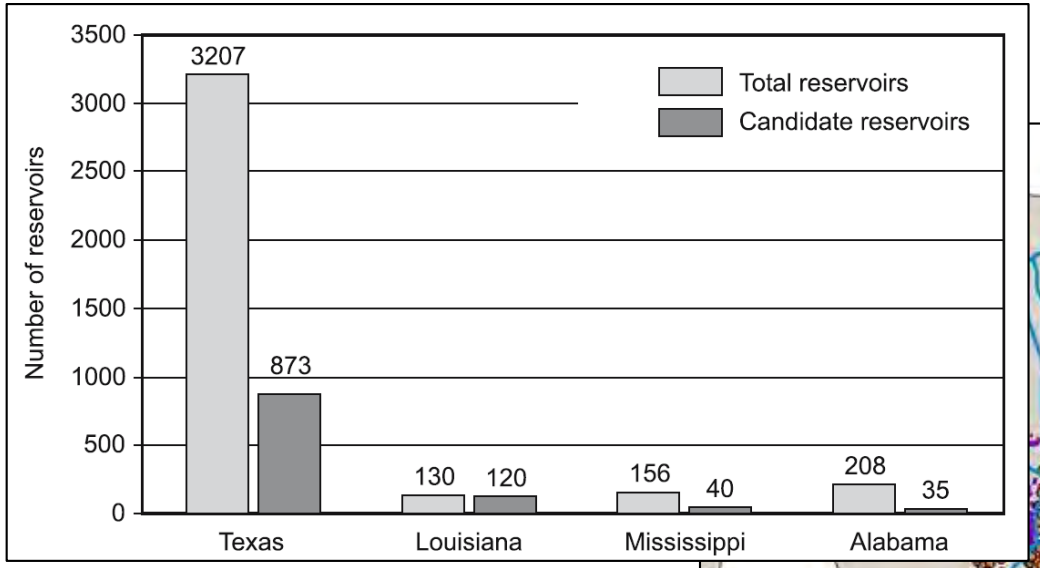
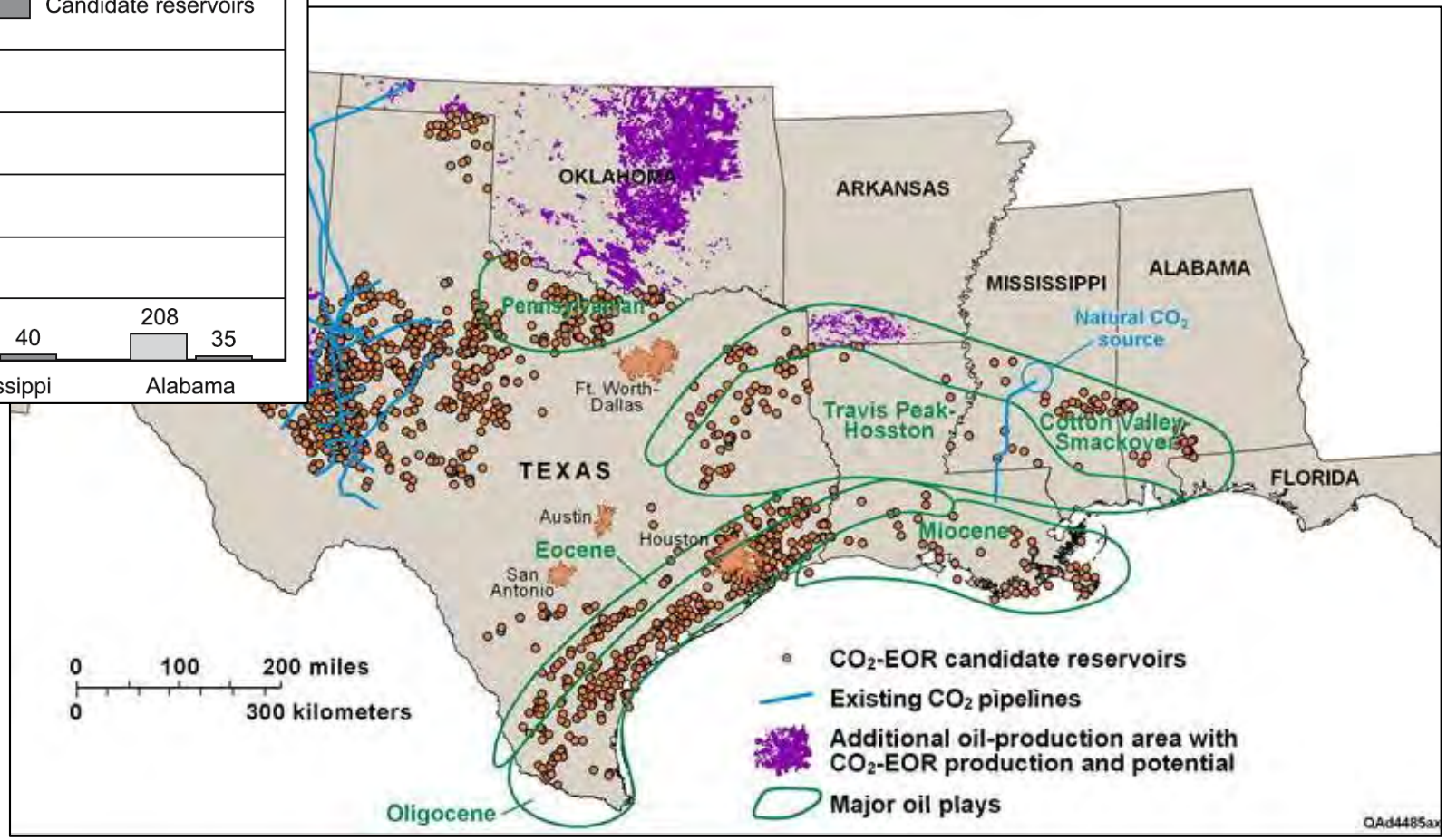
CO_2-EOR

- Long experience
- Familiar geology
- Well developed regulation
- Dual revenue stream

Gulf Coast CO_2-EOR Candidates





- > Min miscibility pressure (or >6000' depth)
- >1mmbbl produced
- Waterflooded or good water drive

Núñez-López et al, 2007

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CO_2-EOR Opportunity

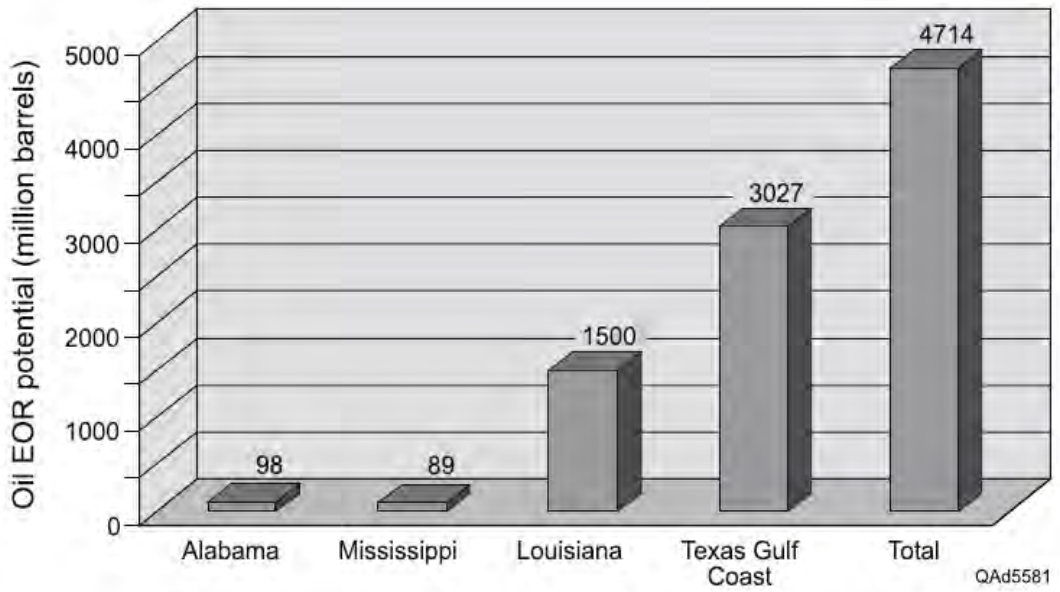

Fig. 6 Bar graph of miscible CO_2 EOR resource potential in the Gulf Coast

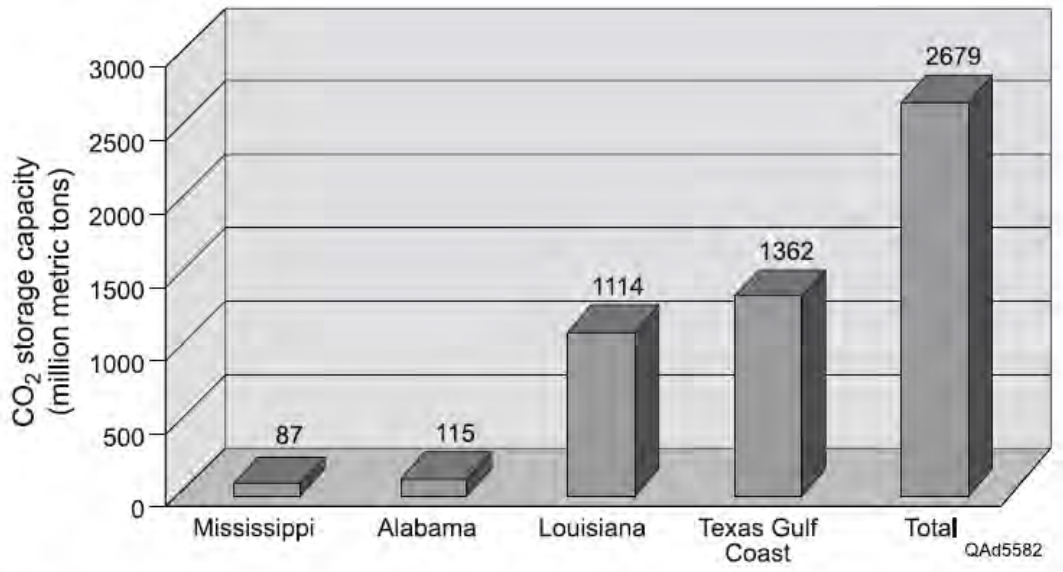

Fig. 7 CO_2 sequestration capacity in miscible oil reservoirs along the Gulf Coast

Núñez-López et al, 2007

4.7Bbbl recoverable oil
2.6Gt CO_2 storage

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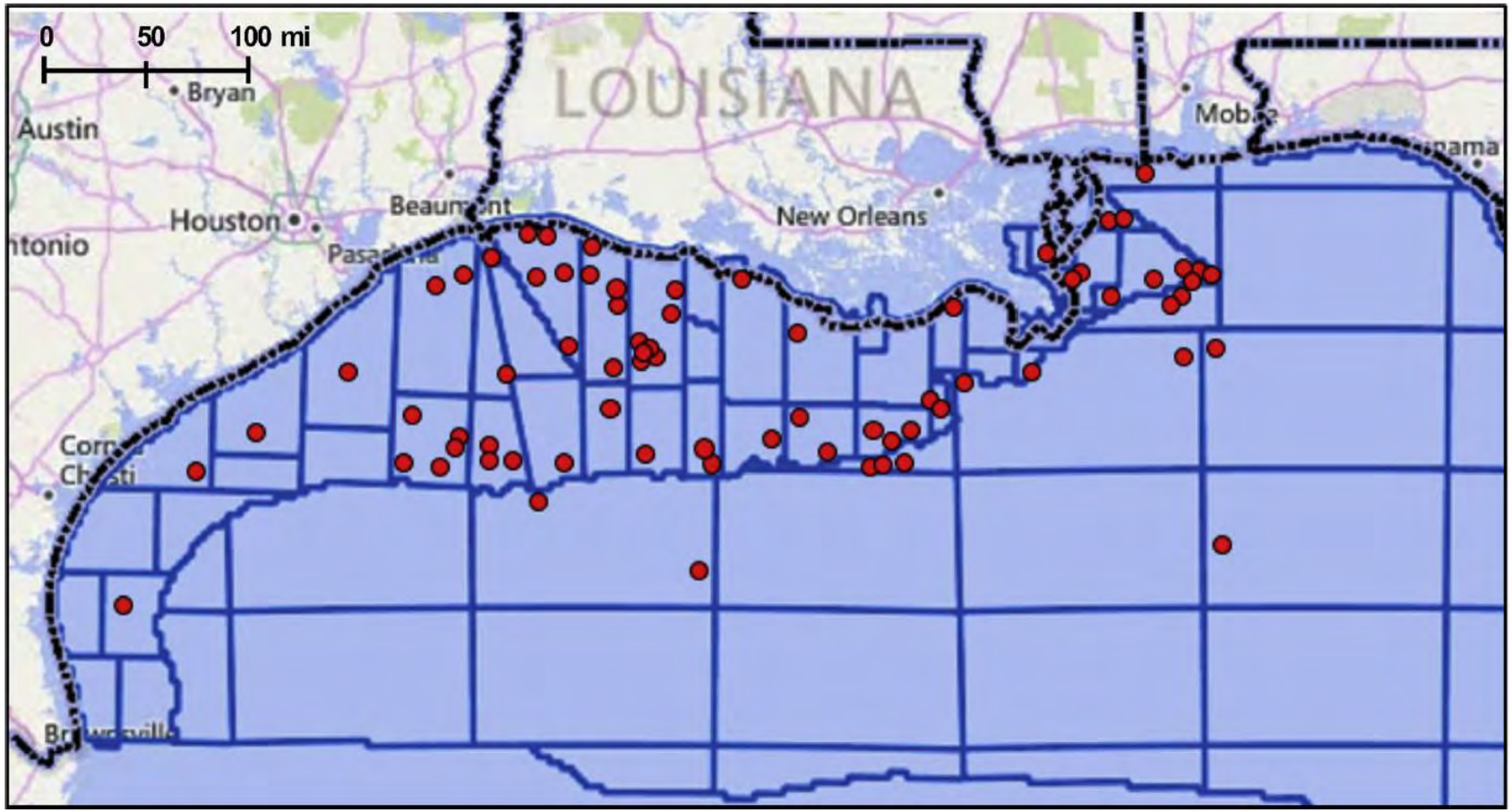
Depleted Field Storage

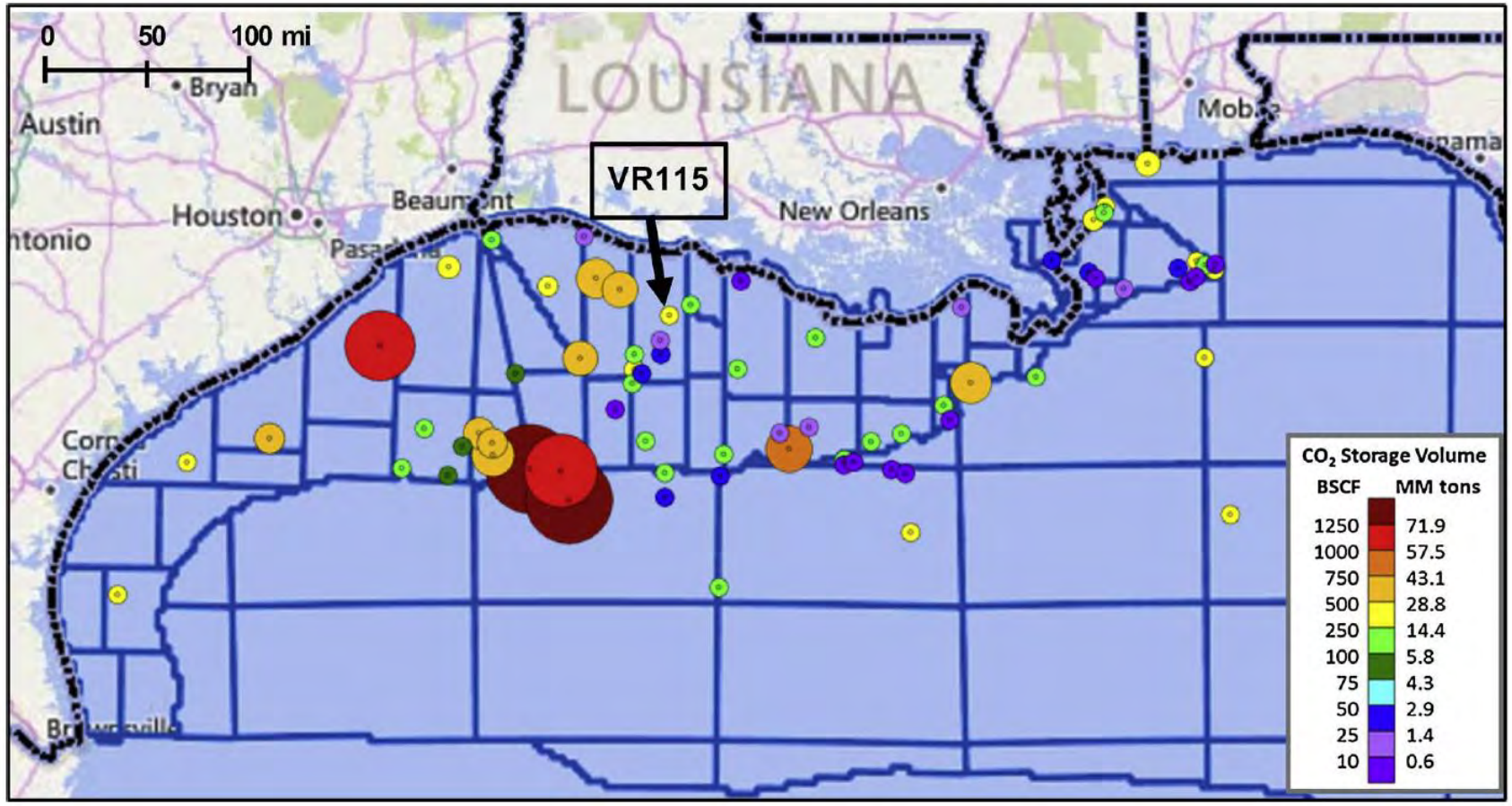
- Familiar geology
- Proven reservoirs, seals and traps
- Chance to extend field life, delay decommissioning
- Possibly re-use infrastructure
- Potential surprises with increasing subsurface pressure
- Immature regulation

GoM Depleted Fields Studied



Agartan et al, 2018

Storage Capacity of Studied Fields



Agartan et al, 2018

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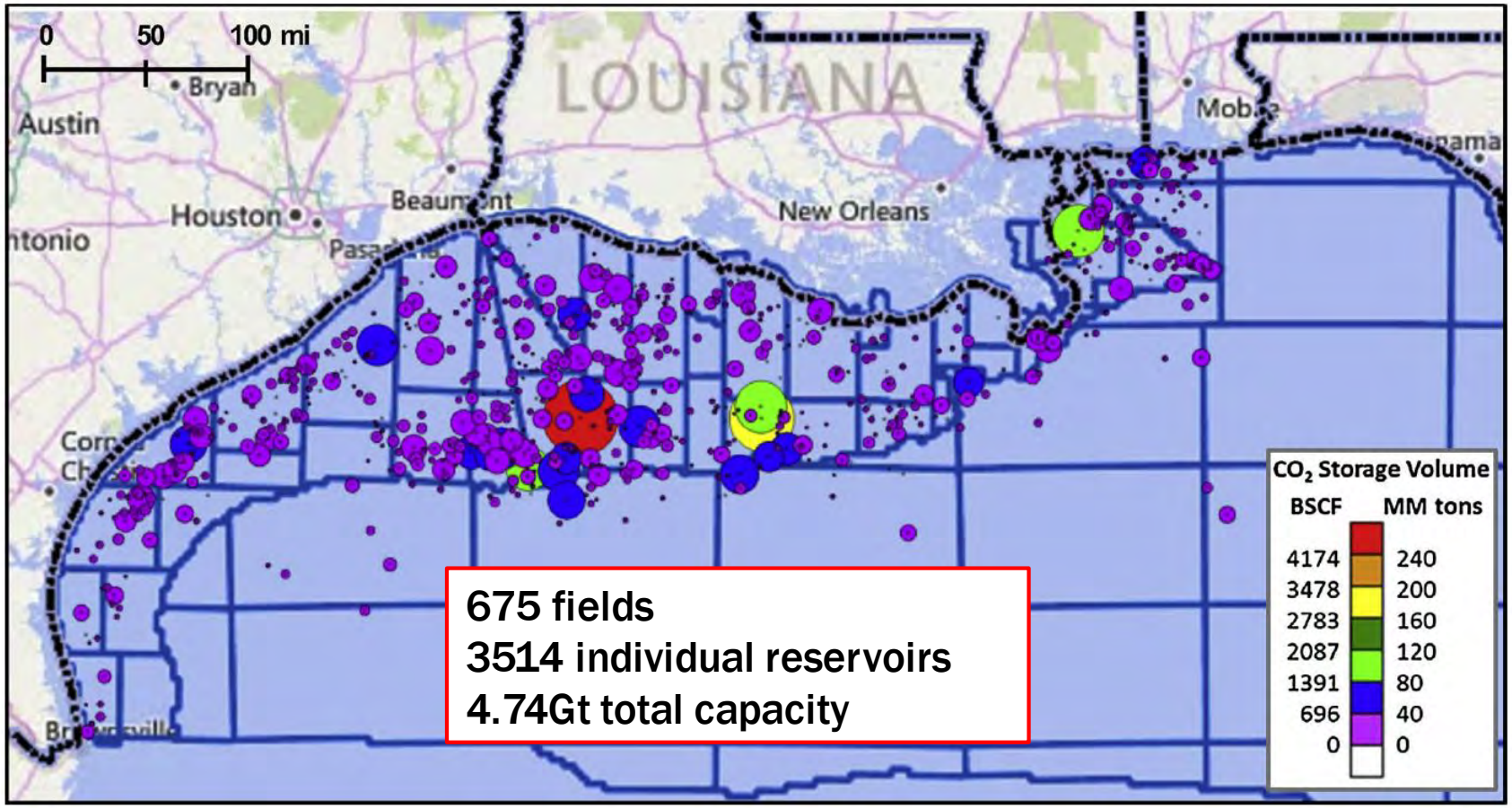
Extrapolated Storage Capacity



Agartan et al, 2018

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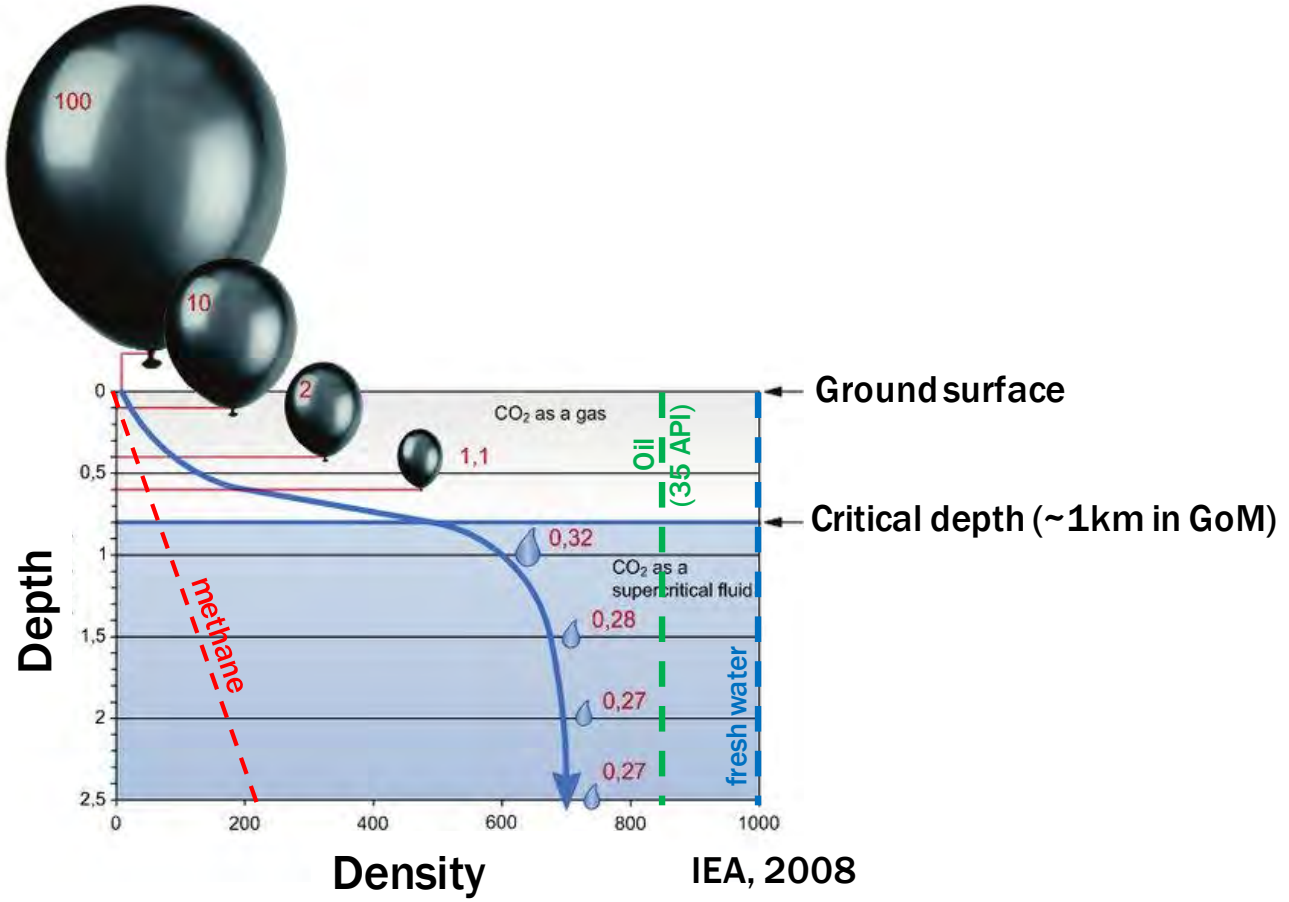
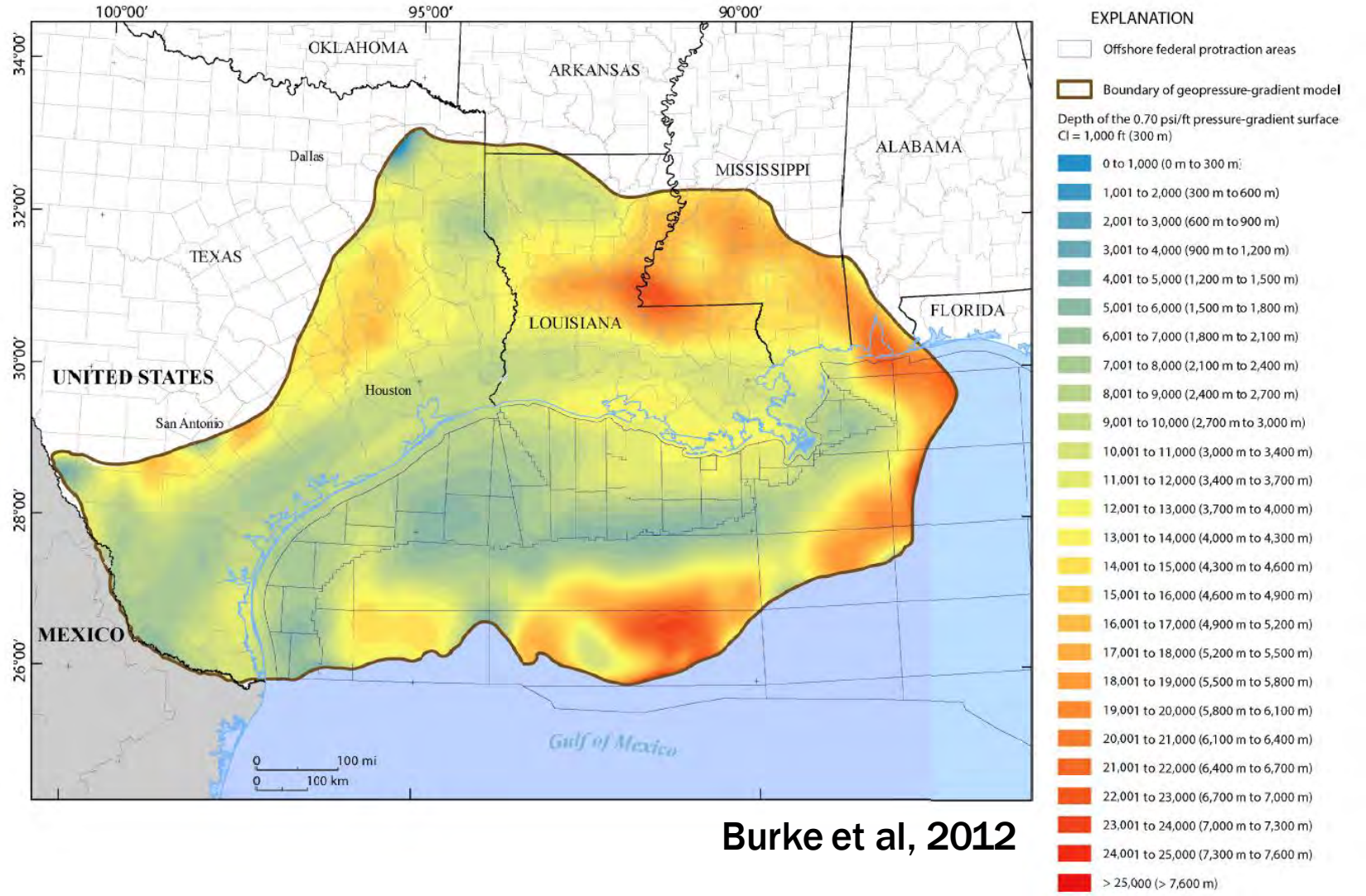
Saline Storage

- Greenfield development
- Familiar geology, but….where would you go to optimize storage?
- Not bound by current or historic hydrocarbon production
  - New locations are possible
  - New plays are possible
- Immature regulation
- The new frontier

CO_2 Density


100
10
2
1,1
0,32
0,28
0,27
0,27
CO2 as a gas
CO2 as a supercritical fluid
Oil (35 API)
fresh water
methane
Depth
Density
0
0,5
1
1,5
2
2,5
0
200
400
600
800
1000
Ground surface
Critical depth (~1km in GoM)
IEA, 2008

Depth to Top of Overpressure



Burke et al, 2012

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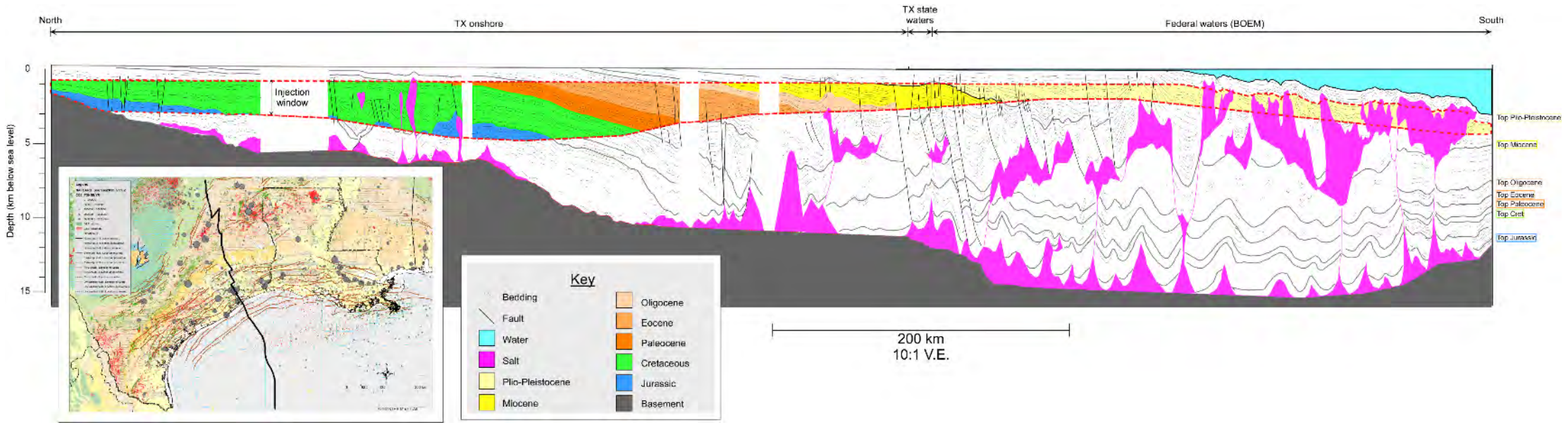
Gulf of Mexico Storage Window

Gulf Coast Cross-section, Dallas to Deepwater



Window for CO_2 storage defined by minimum pressure for supercritical CO_2 (~1km) and top of overpressure

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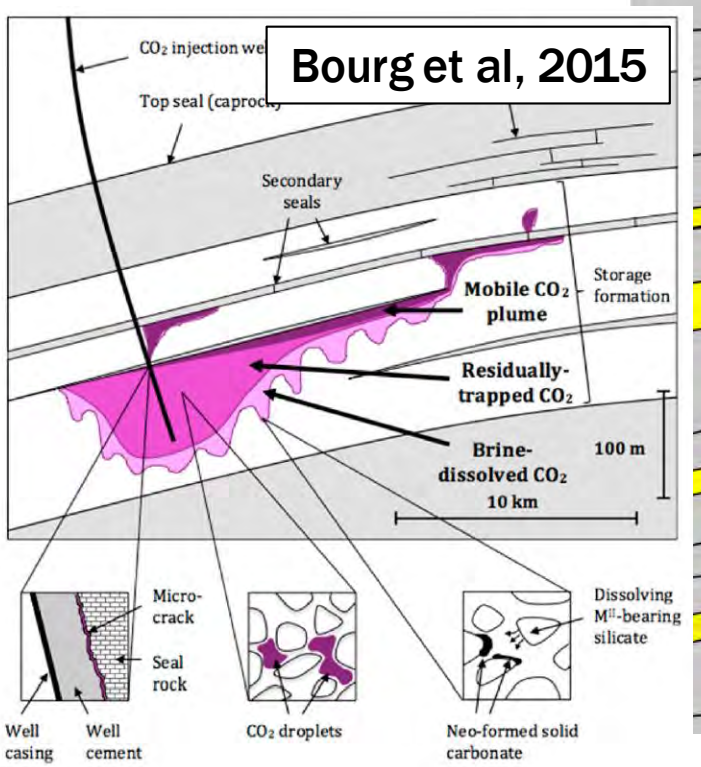
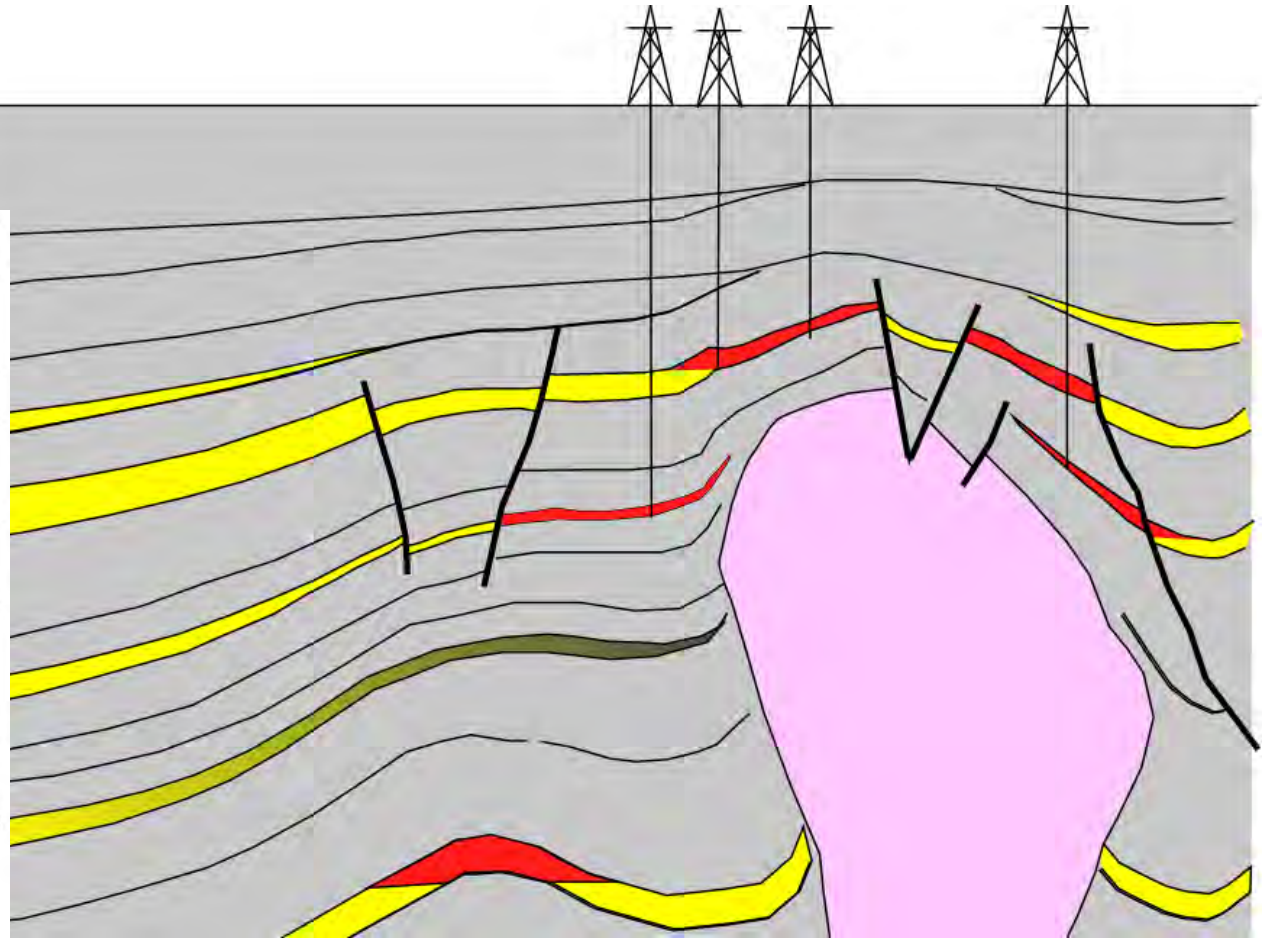
Trapping





Buoyant trapping: Works for both hydrocarbons and CO_2

But we don't want the CO2 back—migration losses are viable storage

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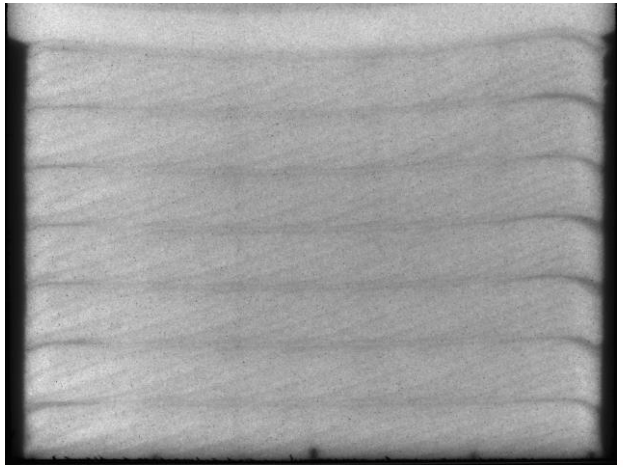
Modelled CO_2 Injection into Brine

Chris MacMinn, Oxford University

CO_2 concentration

0% 100%

Reservoir



Meckel et al, 2019

Familiar tanks of sand—fantastic for hydrocarbons

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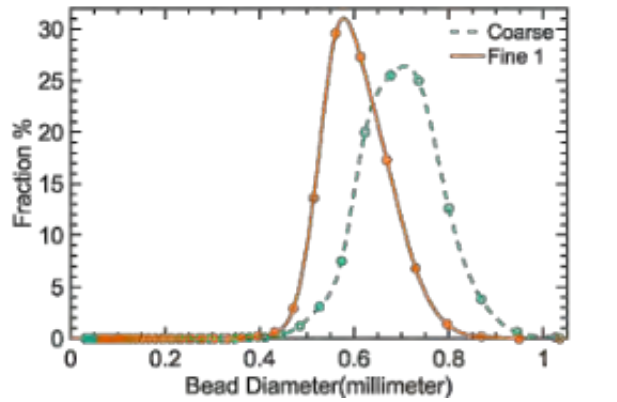
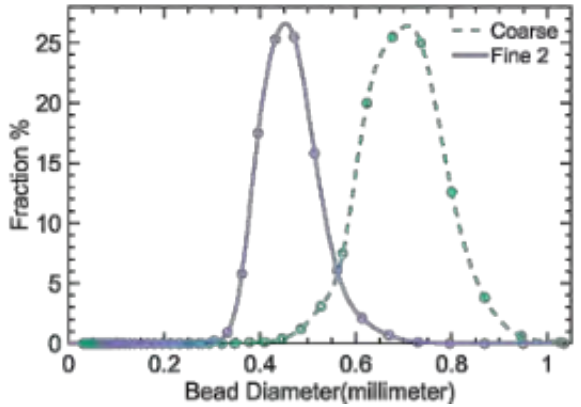
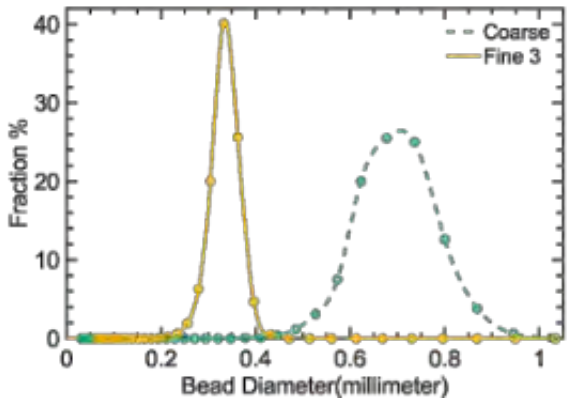
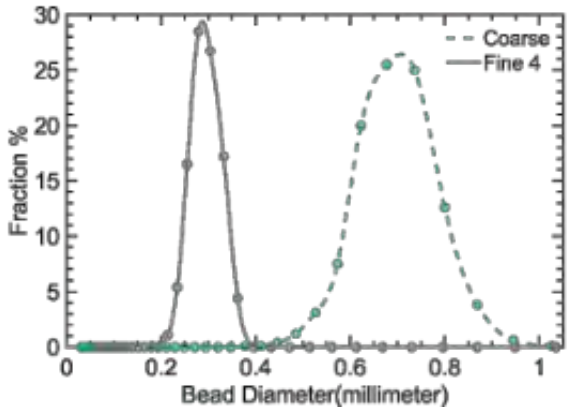
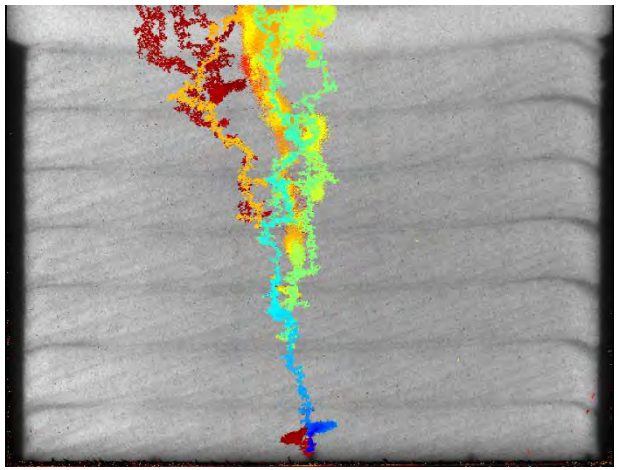
Reservoir: For CO_2 Heterogeneity is useful

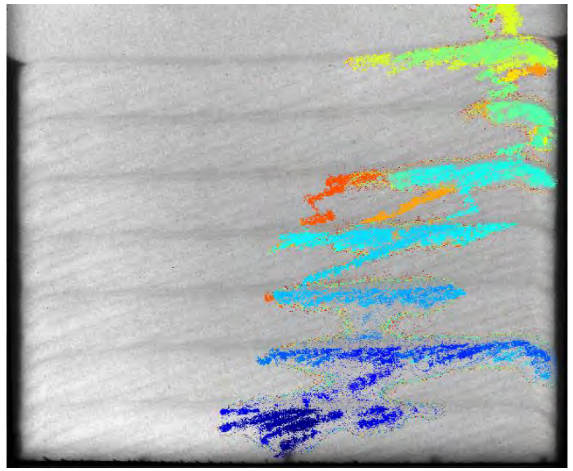


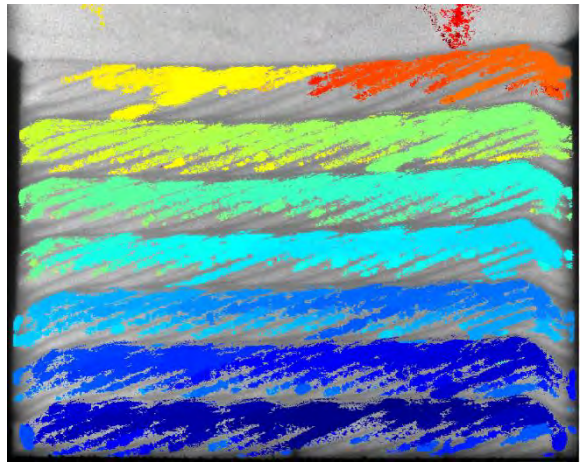


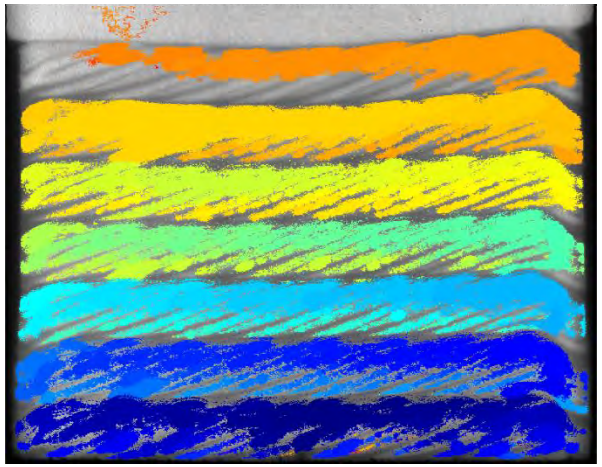












6.5 min

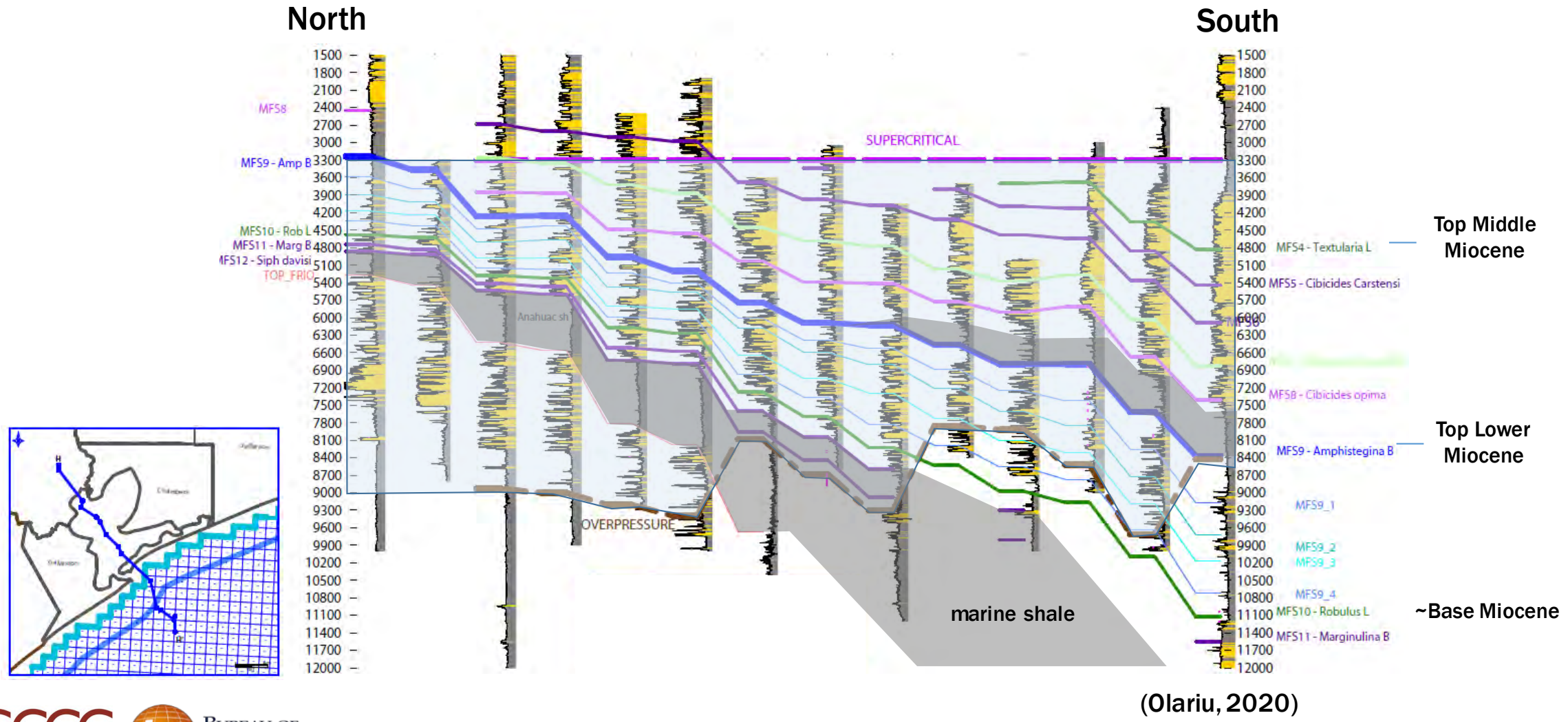
273 min ~4.5 hrs

2665 min ~ 44 hrs

3336 min~55 hrs

Meckel et al, 2019

Seal



(Olariu, 2020)

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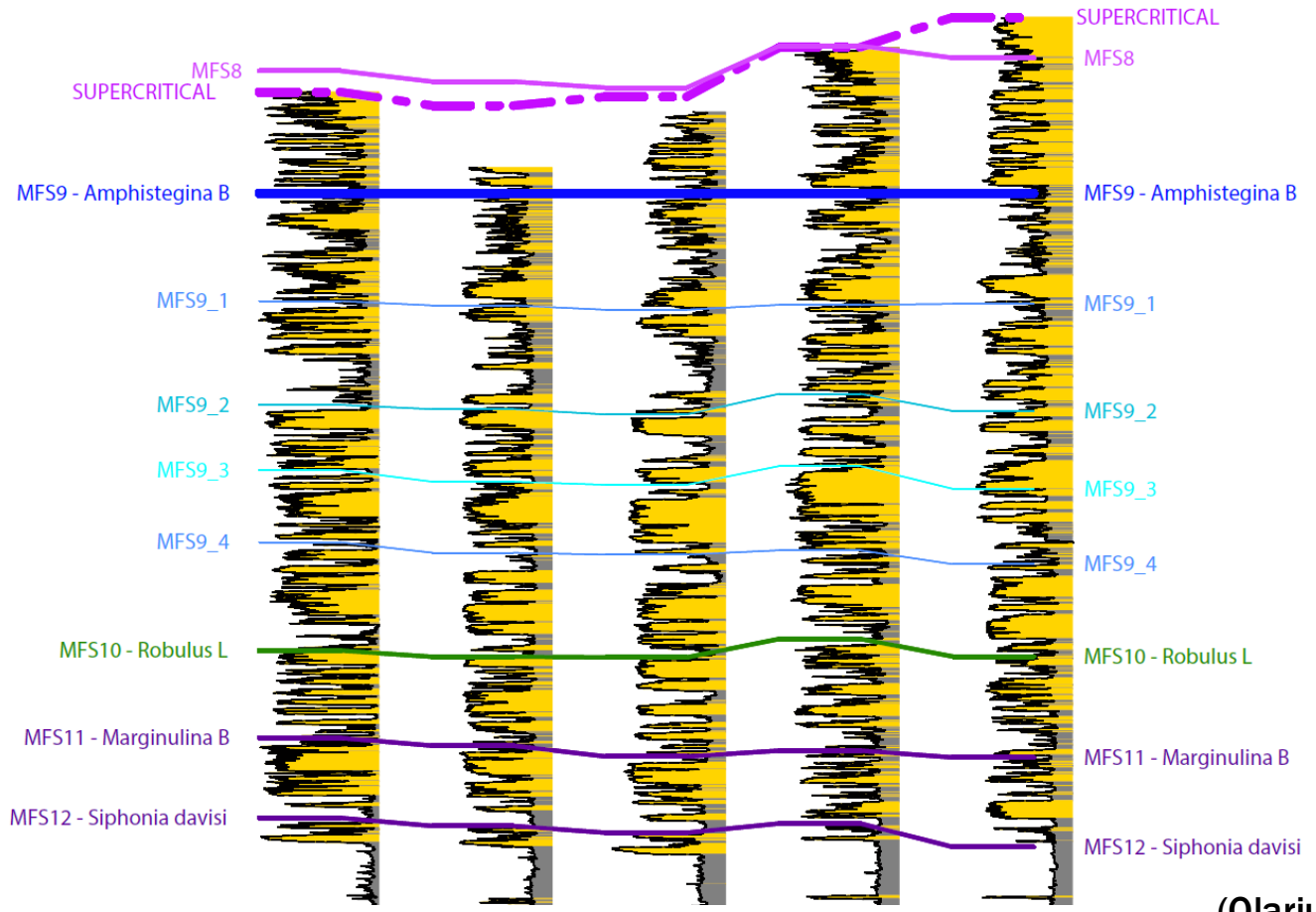
Classic marine shale seals but also baffled “confining systems”

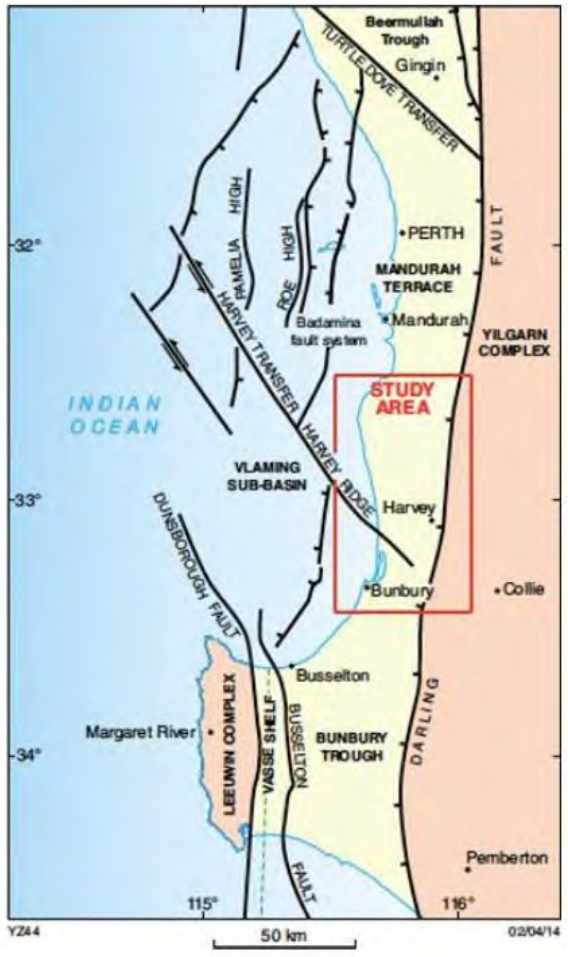
Containment Systems

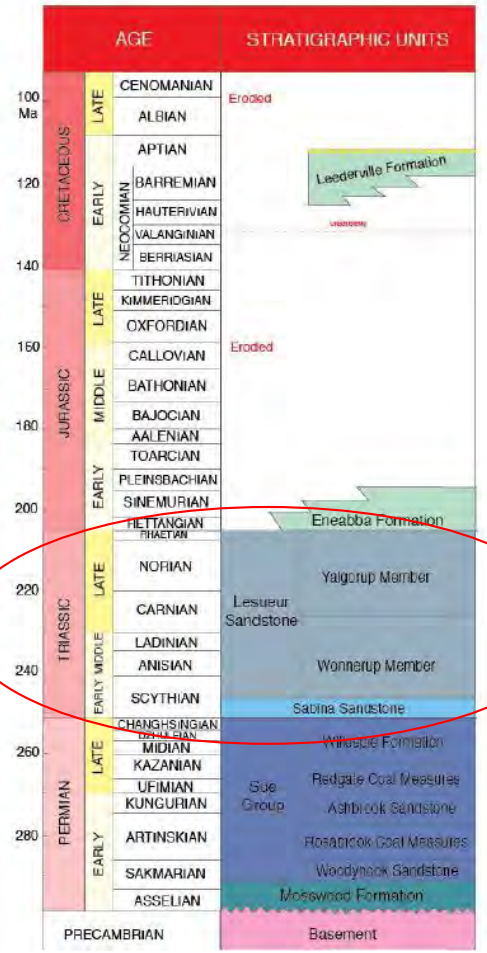


(Olariu, 2020)

A sufficiently baffled, tortuous flow path may be enough to permanently retain CO_2

Southwest Hub





Triassic fluvial systems with discontinuous paleosols and overbank muds

Sharma et al, 2017

Project to store Perth industrial emissions
Very limited onshore storage options, no regional seals

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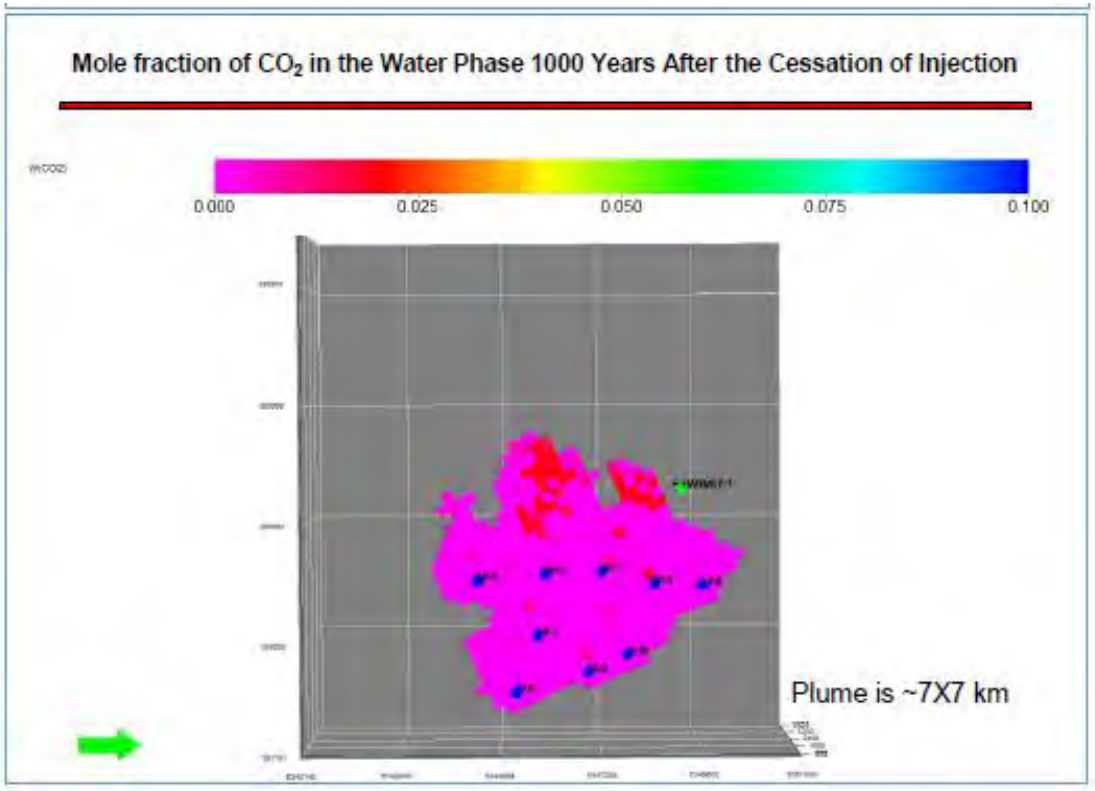
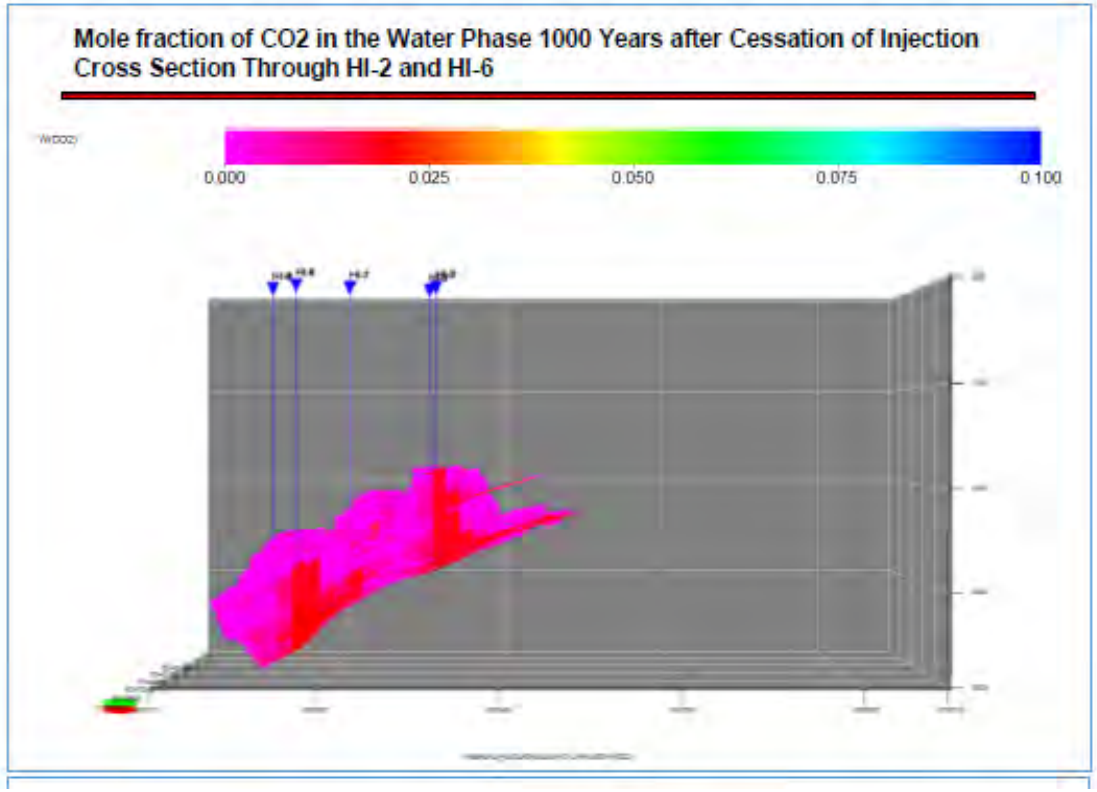
Seal: Southwest Hub Plume Model





- Injection at ~3200m depth
- 800kt/yr for 30 yrs, followed by 1000 yrs shut-in
- Plume is completely contained below 2400m
- For finite injection volumes, baffles can be enough

Sharma et al, 2017

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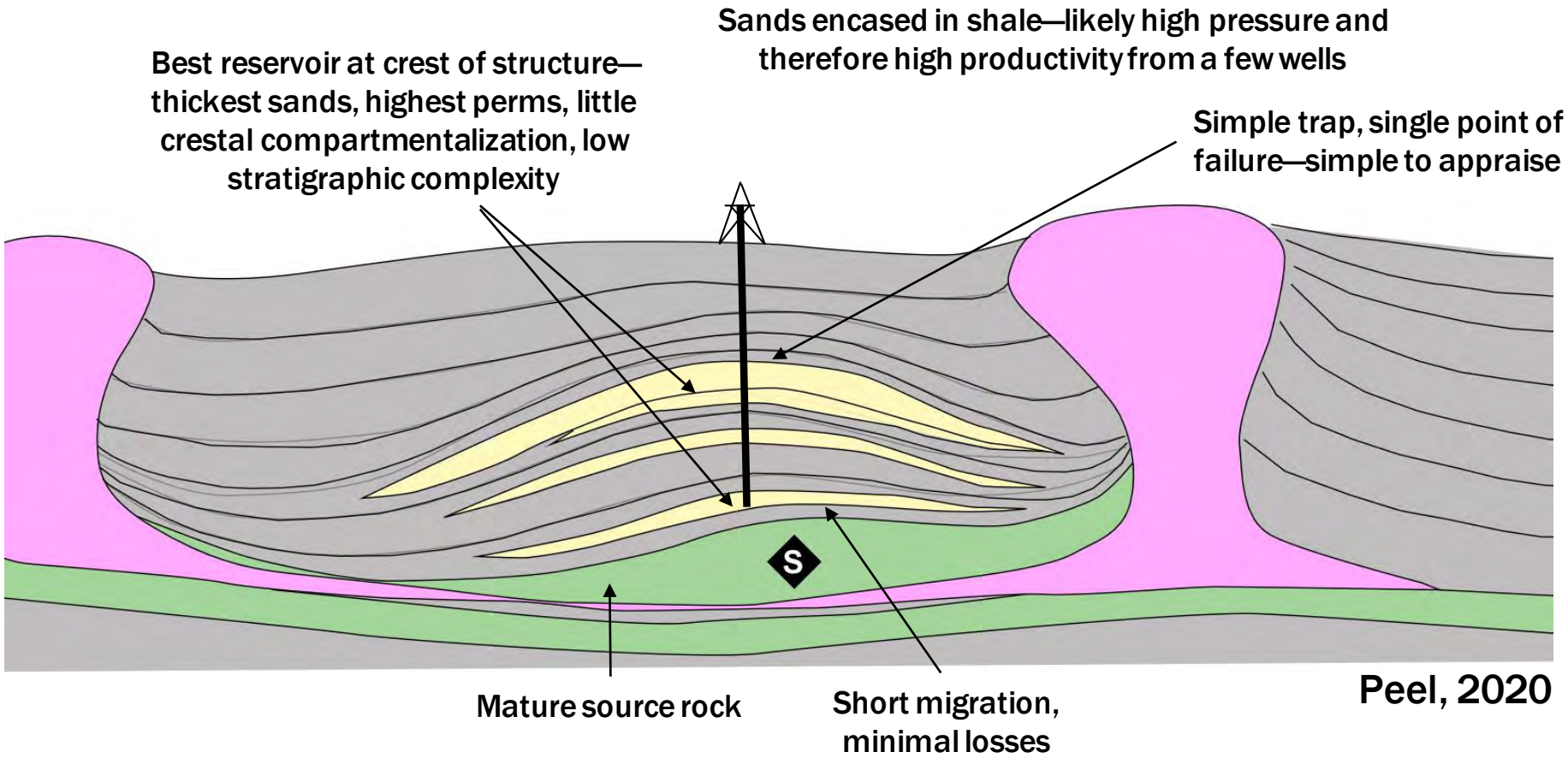
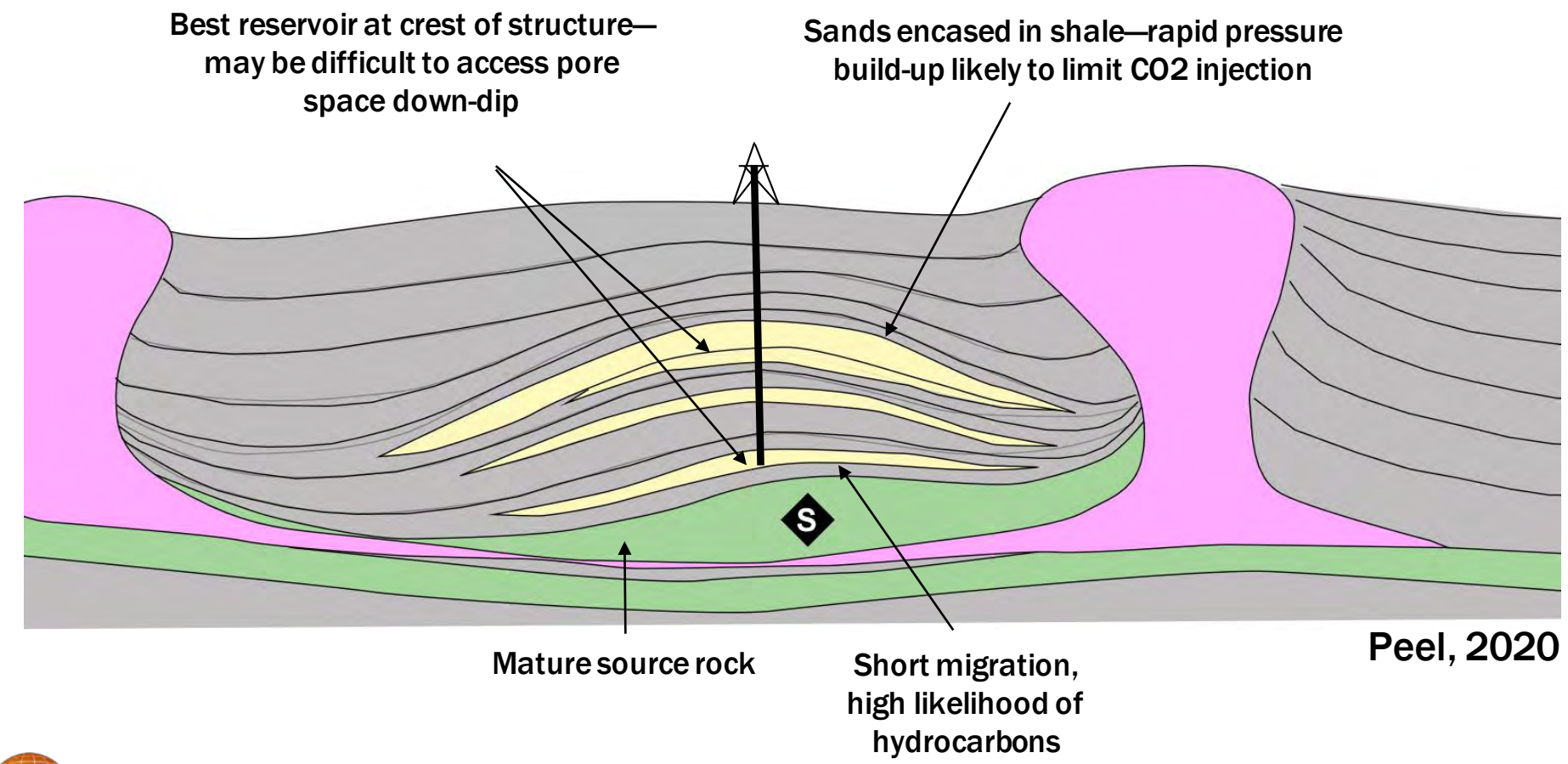
Turtle Play: Great for Petroleum



Peel, 2020

Turtle Play: Not so good for CCS



Peel, 2020

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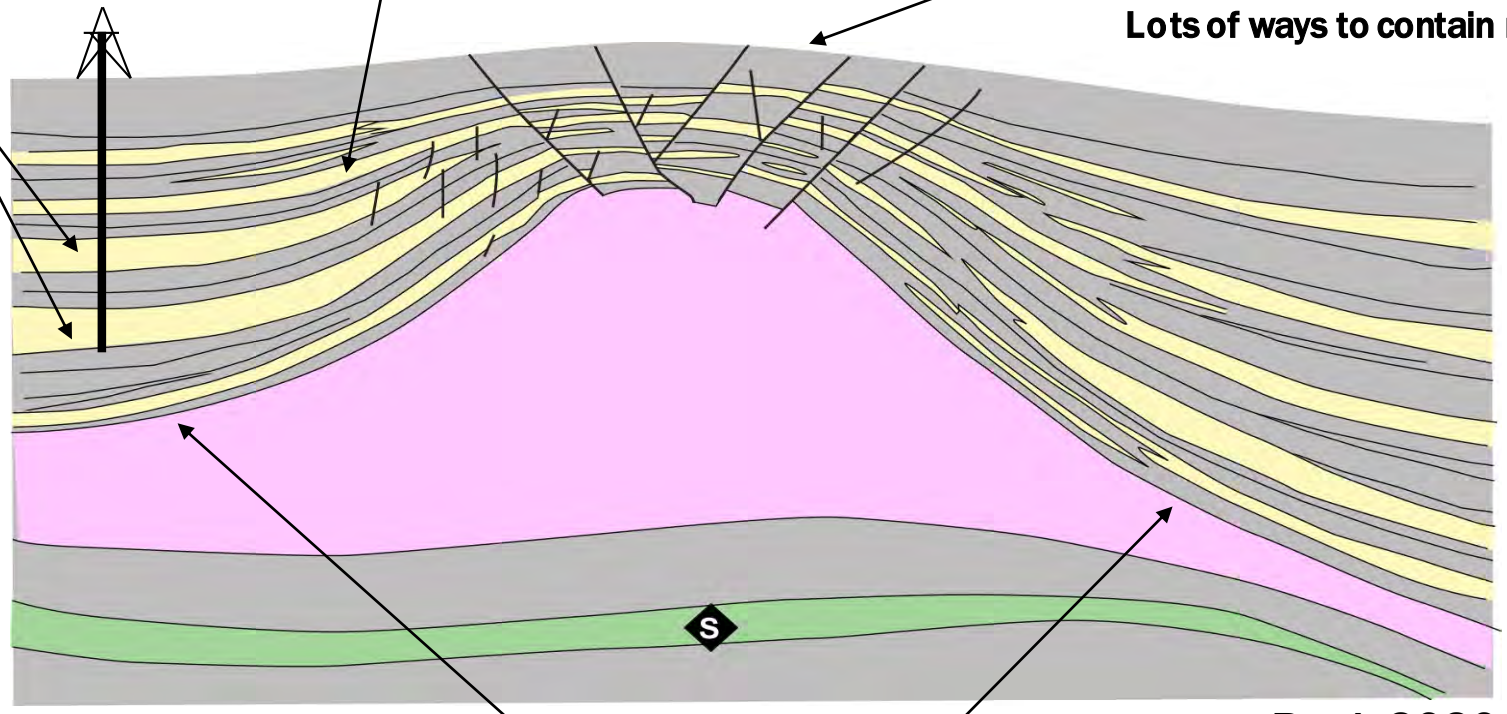
Salt Roller: Better for CCS

Best reservoir in synclines:
- high injectivity down-dip
- Good aquifer connection mitigates pressure buildup

Lots of running room for injected CO_2
Stratigraphic complexity spreads plume, improve storage efficiency

Crestal region:
- poor reservoir, poor connectivity
- high compartmentalization
- high stratigraphic complexity

Lots of ways to contain migrating CO_2



Peel, 2020

Salt-floored basin, not connected to source:
Fewer wells, no competing uses

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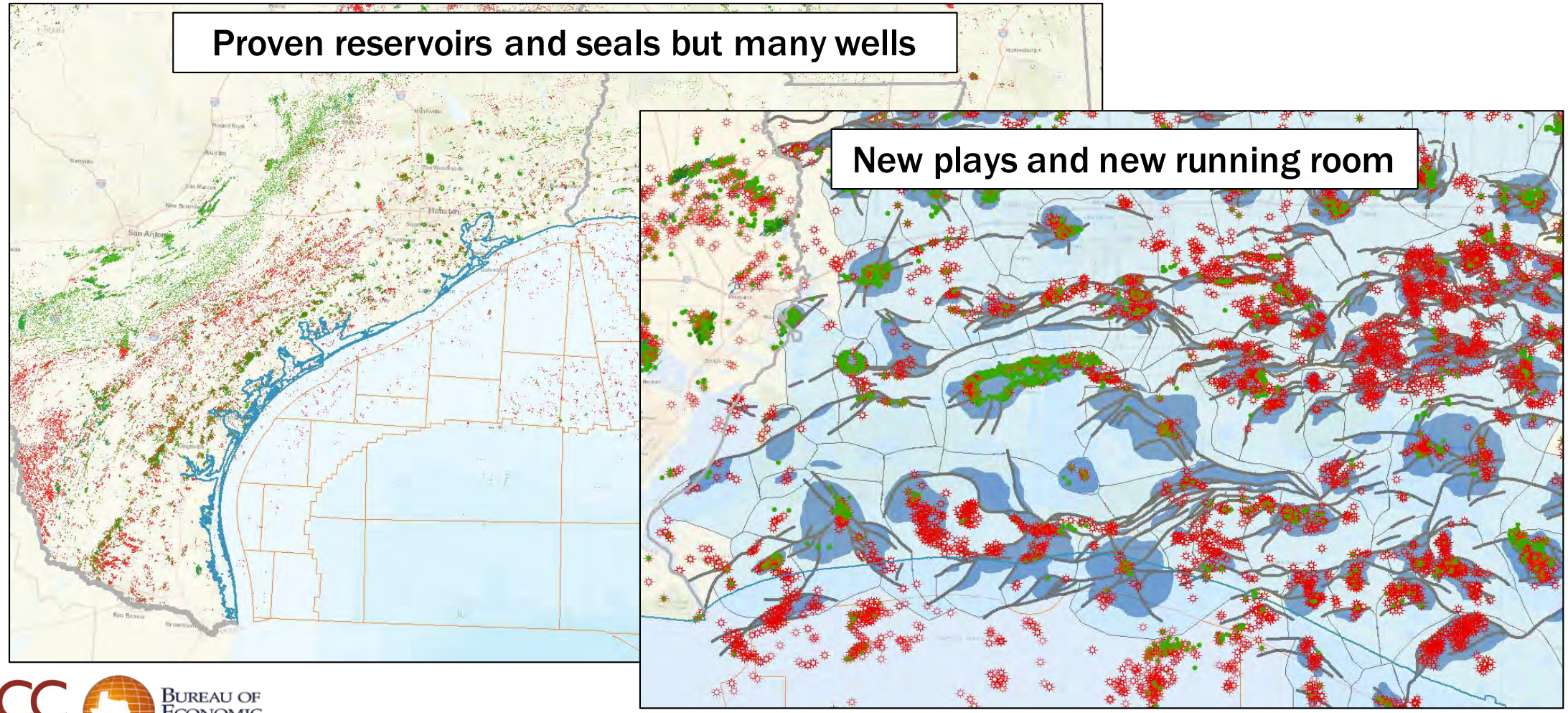
Gulf Coast CCS



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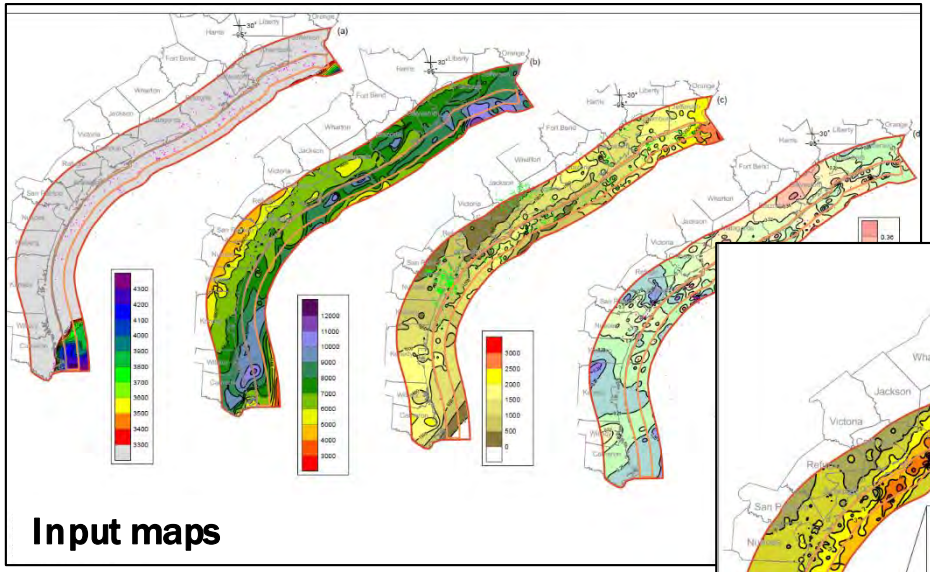
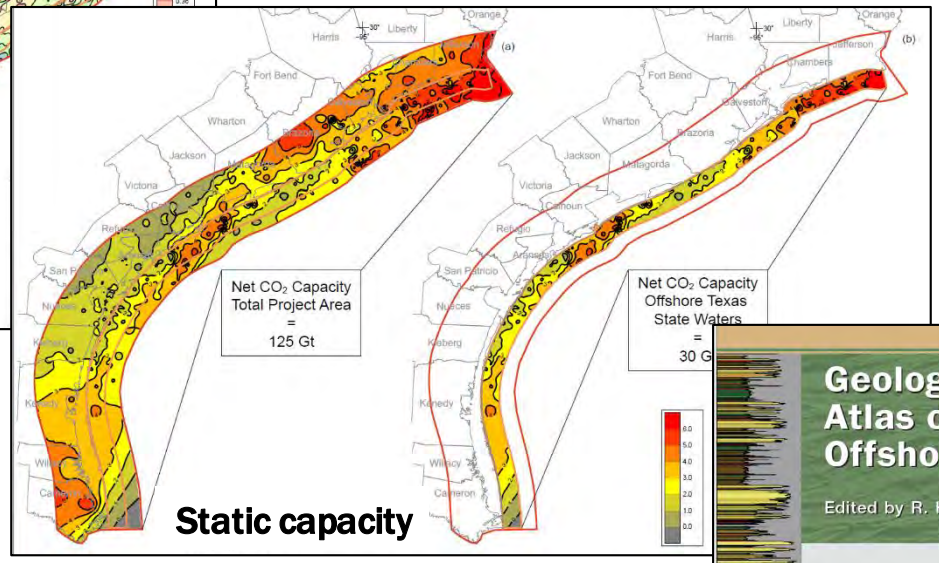
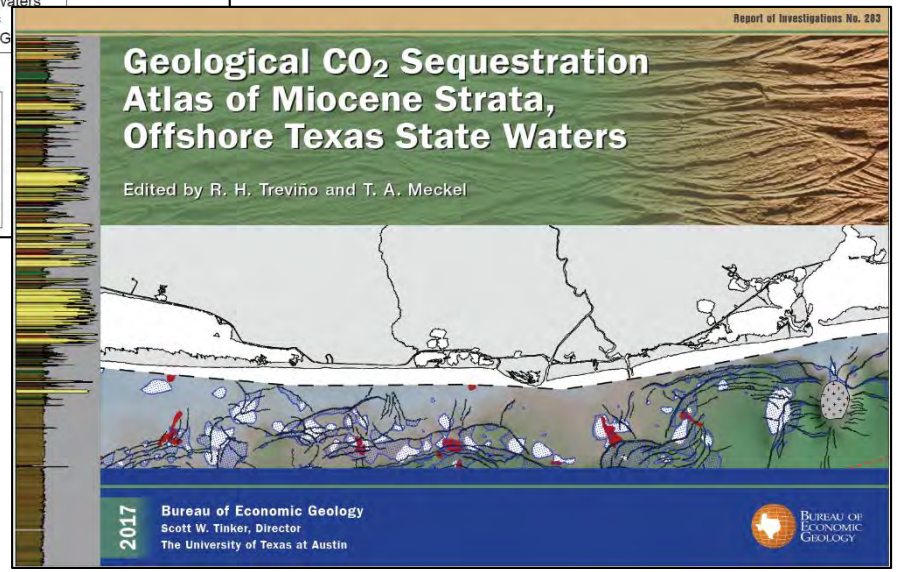
Gulf Coast Saline Storage Capacity





Treviño and Meckel, 2017



125Gt in TX coastal Miocene section
30Gt in TX Miocene section in state waters

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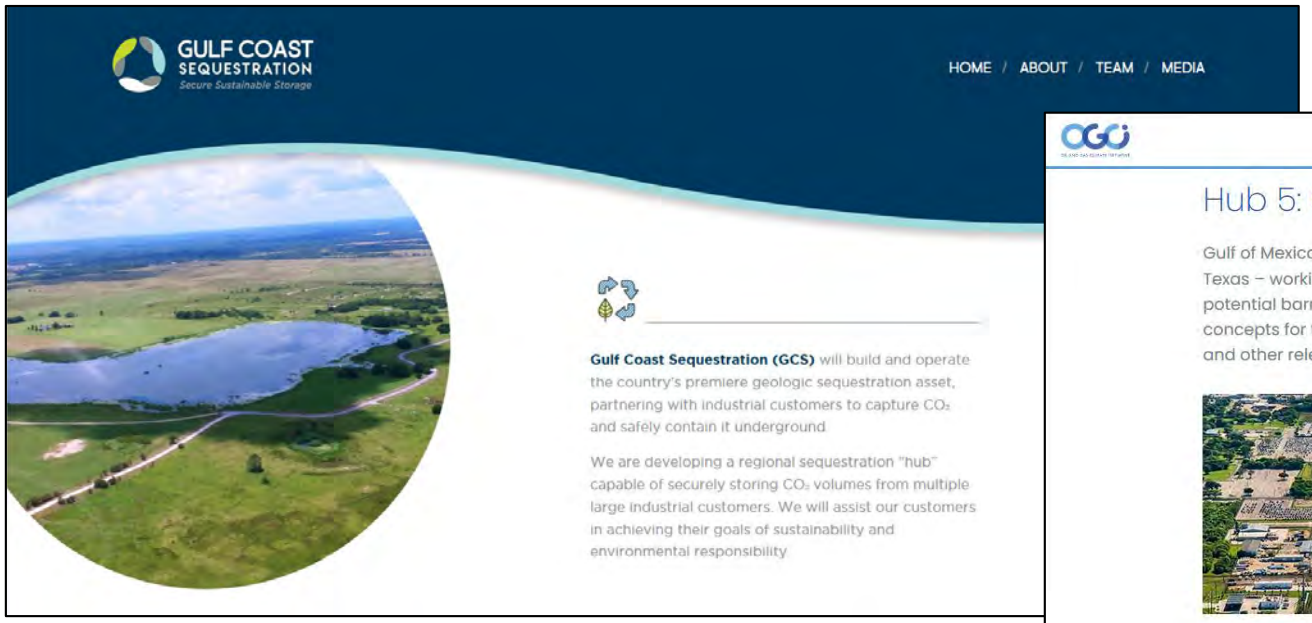
Gulf Coast CCS: Projects underway



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Comparing Storage Schemes

Storage Scheme	Key Considerations	Gulf Coast Scale
CO2-EOR	• Dual revenue stream, proven business model • Use existing facilities • Mature permitting/regulation • Limited suitable locations	~5Gt?
Storage in depleted fields	• Brownfield redevelopment--new revenue stream, delayed decommissioning • Proven seals and reservoirs • Compact footprint to monitor • Immature permitting/regulation	~10Gt?
Saline storage	• Giant capacity, large running room • Widely available • Take advantage of new plays • Immature permitting/regulation	100s of Gt

Conclusion

- CCS has huge growth potential
- The Gulf Coast is a natural place to do it
- CO2-EOR
- Storage in depleted fields
- Saline storage
  - Same principles as petroleum geology, but there are twists
    - Increasing pressure
    - Don't want it back
    - Focus on seal
  - New plays and new drivers
- A new frontier!

Acknowledgments

DOE NETL

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