TEXAS Geosciences
The University of Texas at Austin
Jackson School of Geosciences

Evaluating, Risking, and Ranking Carbon Sequestration Buoyant Traps with Application to Nearshore Gulf of Mexico

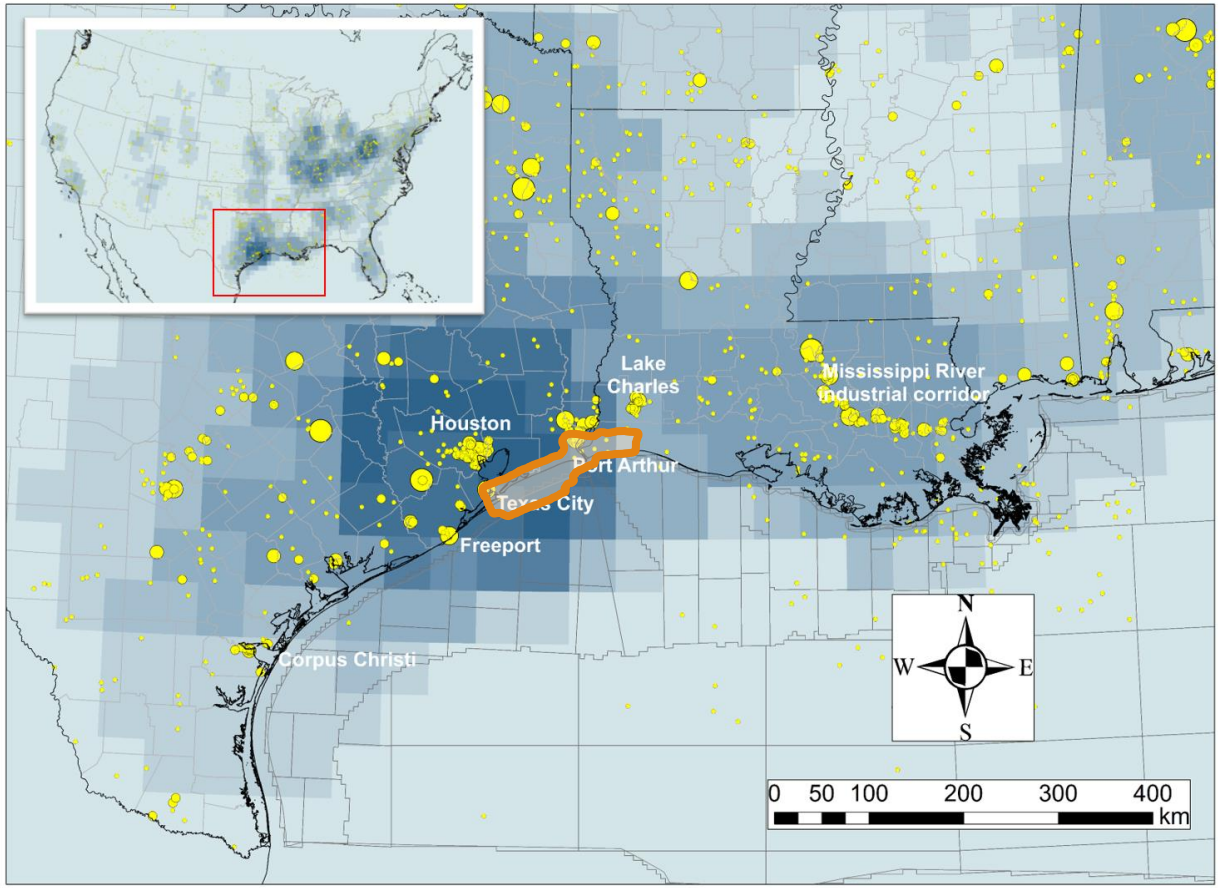
MADDIE LAIDLAW

Masters Saturday April 30, 2022

ENERGY AND EARTH RESOURCES GRADUATE PROGRAM

multidisciplinary studies for interdisciplinary solutions

CCS in the Gulf Coast



(Meckel et al 2021)

- CCS can play a vital role in reducing carbon emissions
- US Gulf Coast is an attractive region to develop CCS
  - Cost lies in capturing emissions
  - Uncertainty lies within subsurface reservoirs
- **How should CCS developers identify high-quality sequestration prospects?**

Outline

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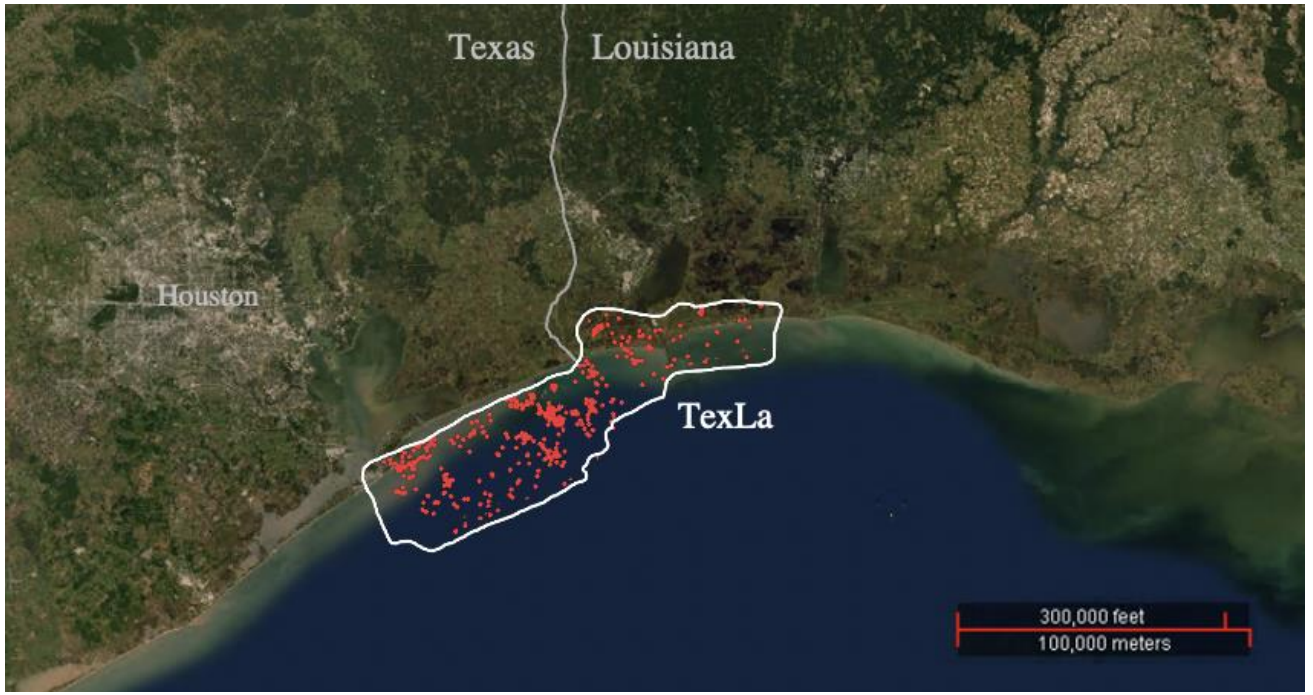
I. Evaluating

- Previous Prospect Inventories
- Creating a New Inventory

II. Risking

- Geologic Risk
- Above Ground Risk

III. Ranking



Carbon Storage Prospect Inventory

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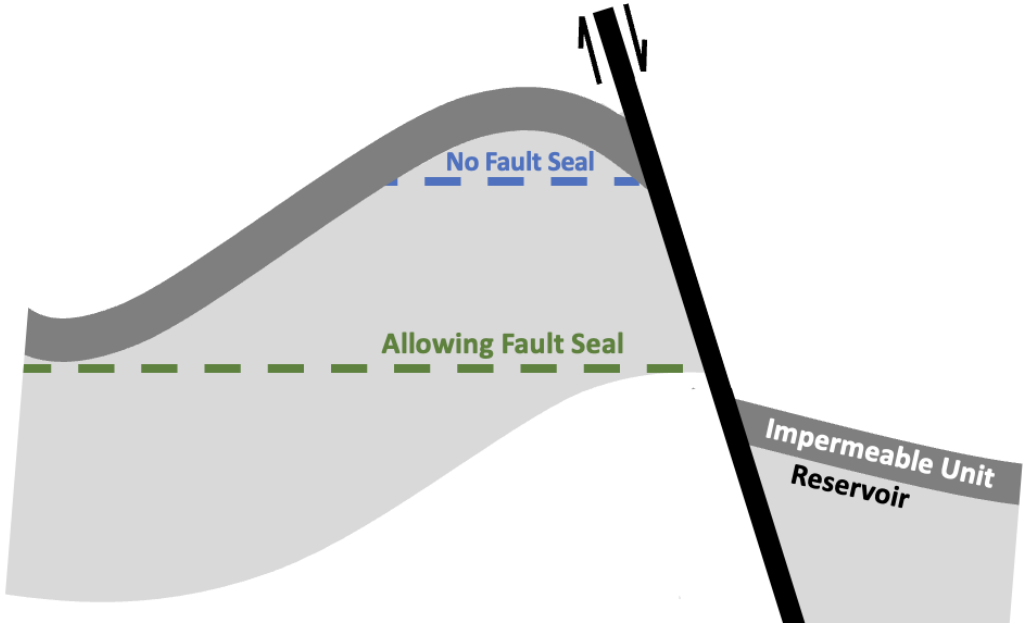
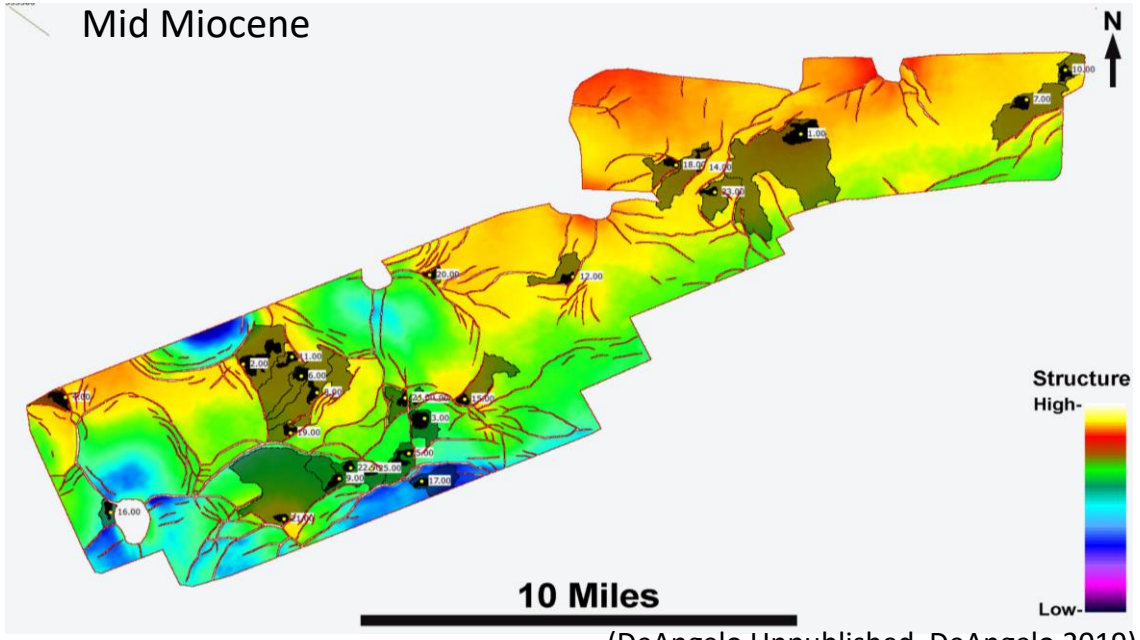
What is a CCS Prospect?



- Individual subsurface sequestration opportunities
- Allowing fault seal expands…
  - Volume of carbon that can be sequestered per prospect
  - Number of prospects to choose between

First Edition TexLa CCS Prospect Inventory



(DeAngelo Unpublished, DeAngelo 2019)

- Used map-based fetch & closure analysis to identify traps
- Excludes the potential for fault seal
- Doesn't reflect our knowledge of GOM stratigraphy

2nd Edition TexLa Prospect Inventory

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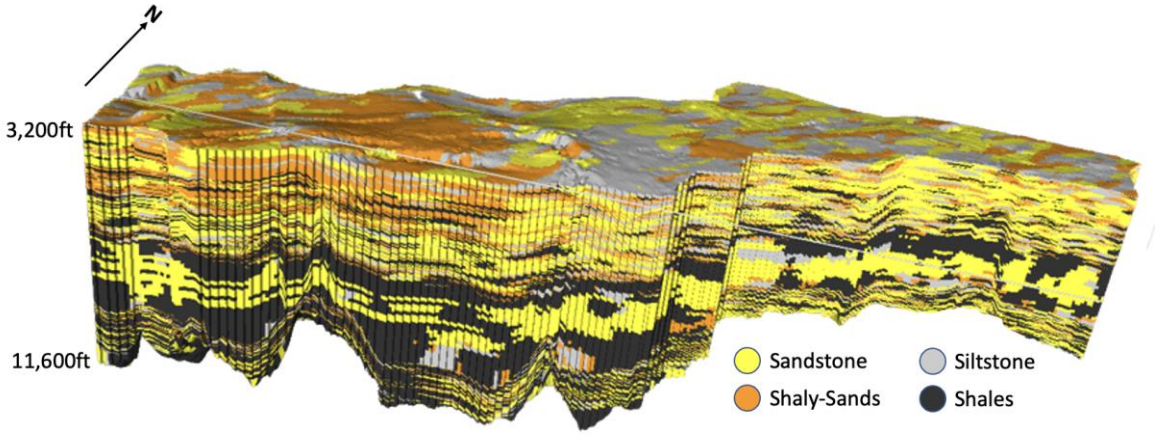
Incorporate real Miocene geologic data…



2nd Edition TexLa Prospect Inventory

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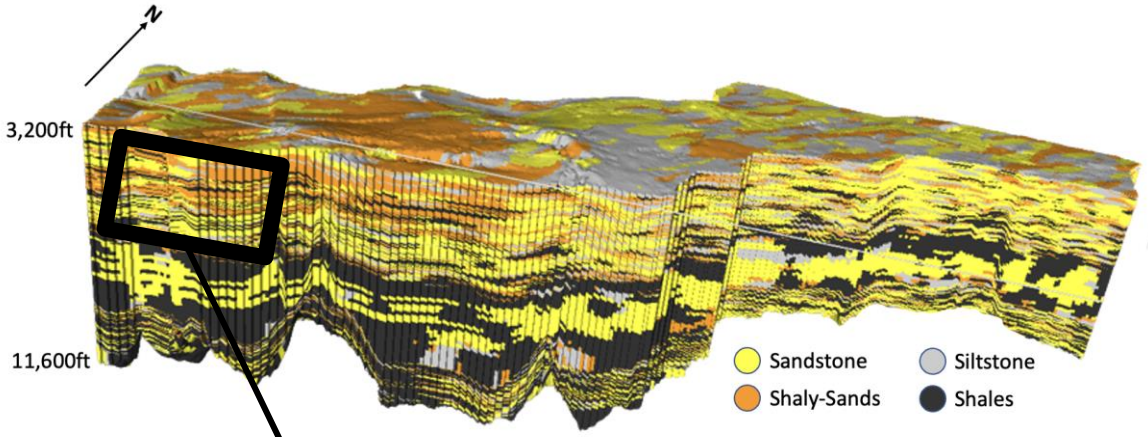
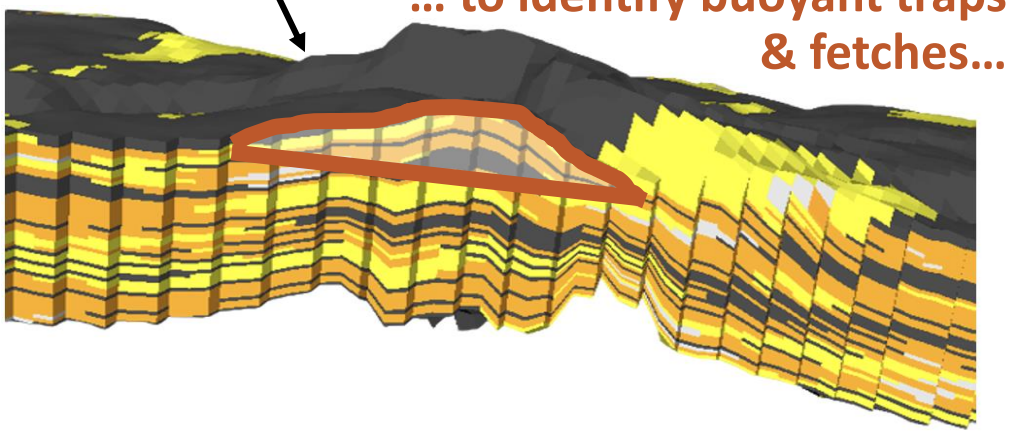


… to identify buoyant traps & fetches…



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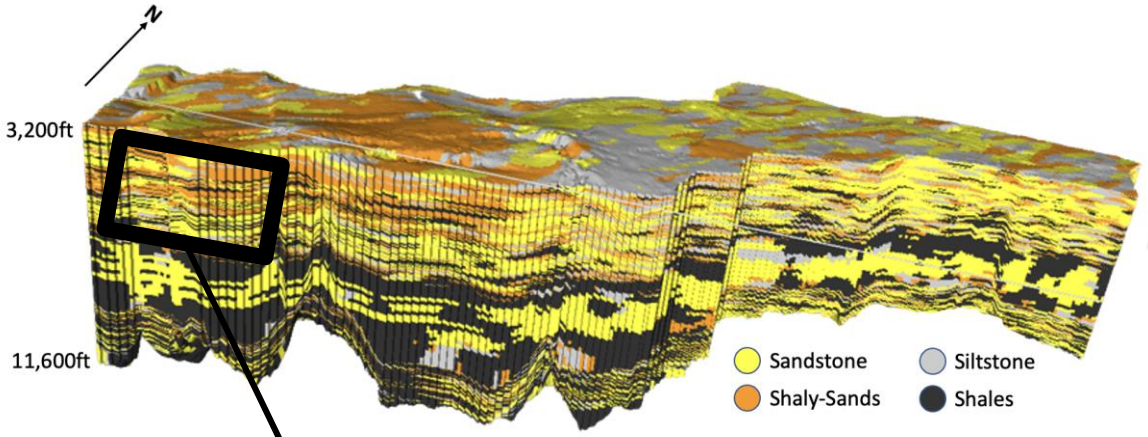

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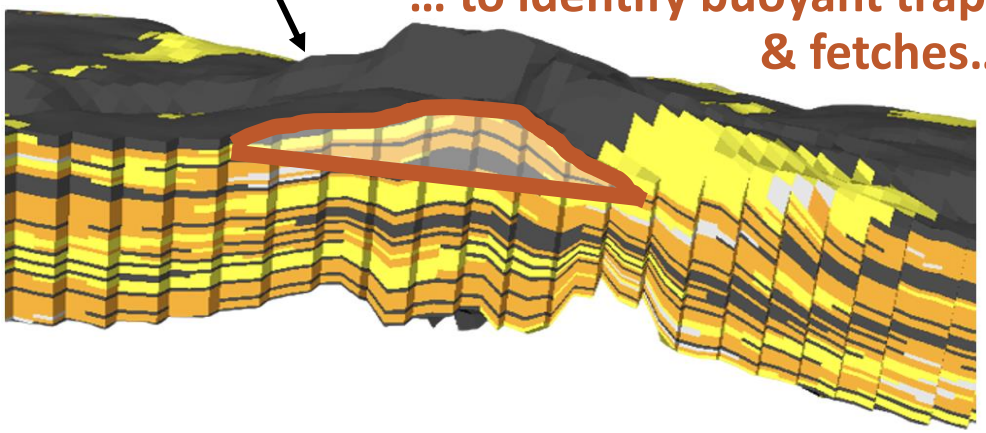
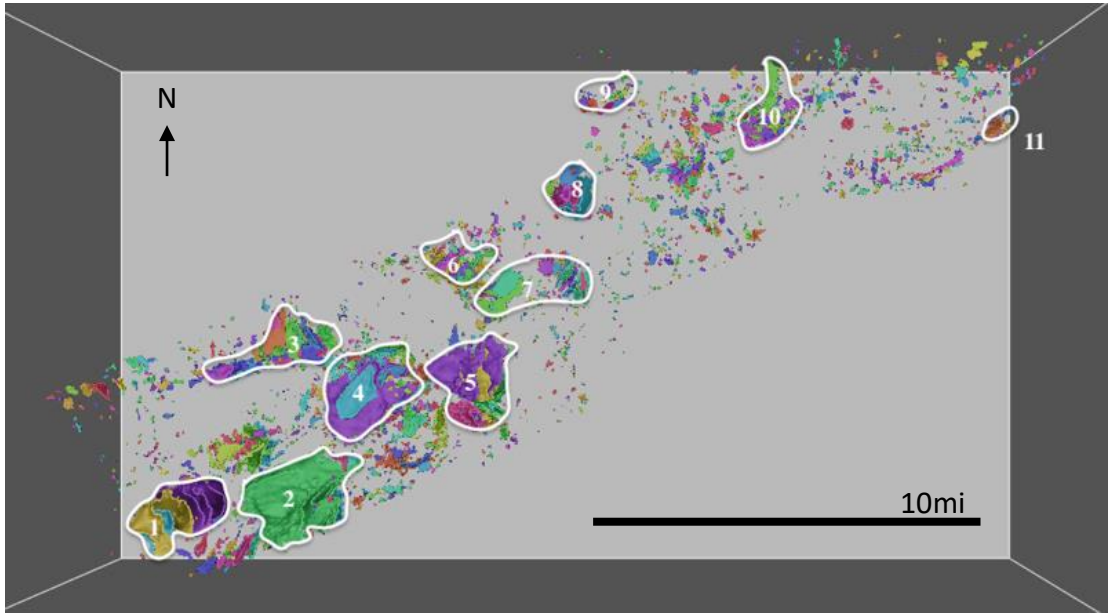
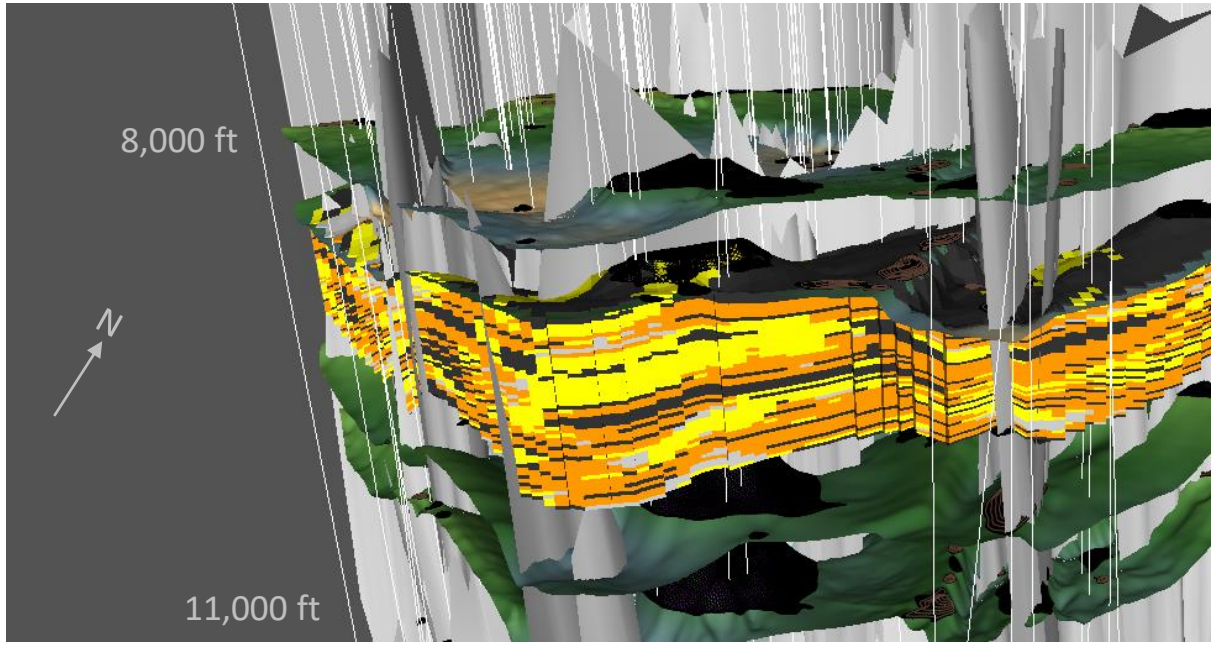


… creating a Multi-Reservoir Prospect Inventory



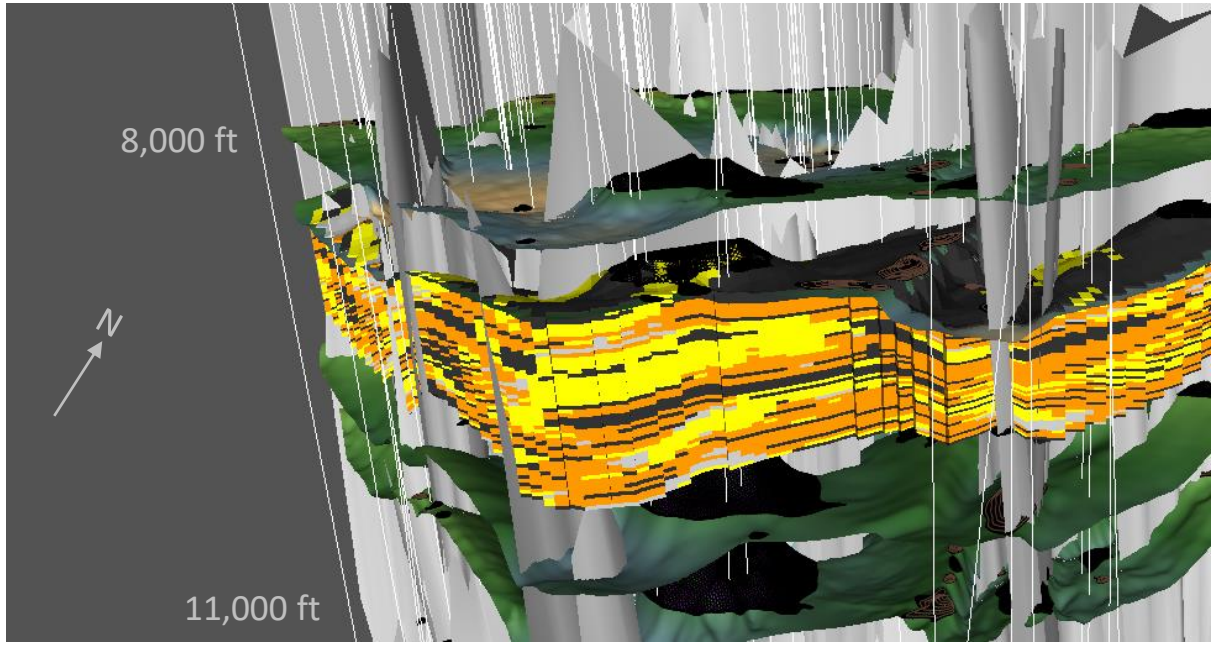
Quantifying Prospect Risk



Subsurface Risk

- How much?
- How fast?
- How secure?

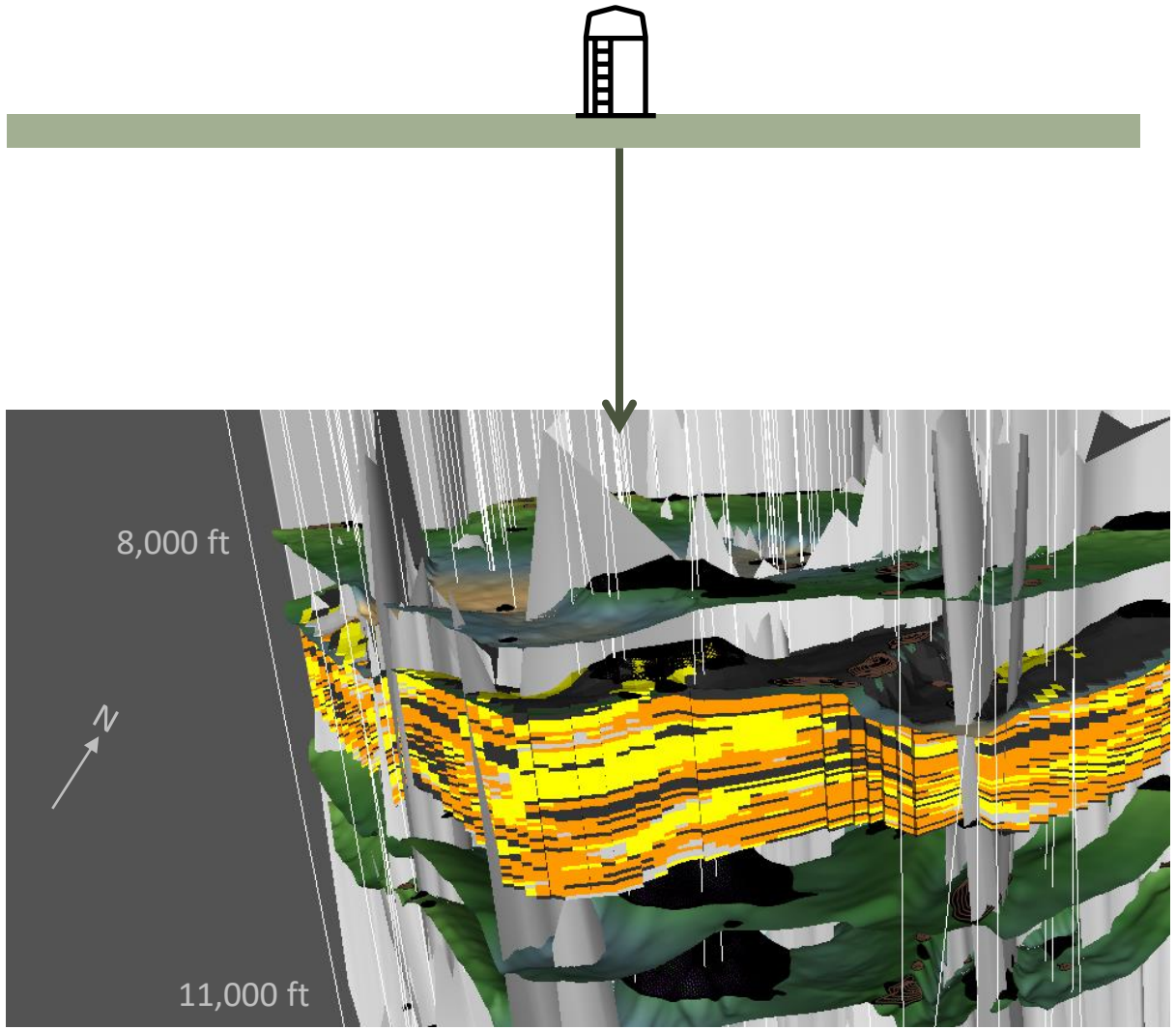
Quantifying Prospect Risk



Subsurface Risk

- How much? Capacity
- How fast? Injectivity
- How secure? Confining Zone

Quantifying Prospect Risk



Above-Ground Risk

- **Financial**
- Political
- Permitting

Subsurface Risk

- **How much?** Capacity
- **How fast?** Injectivity
- **How secure?** Confining Zone

Capacity Risk

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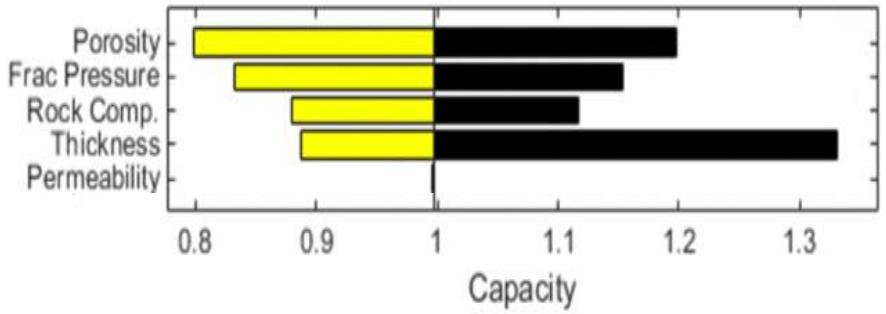
How much CO_2 can a prospect store?

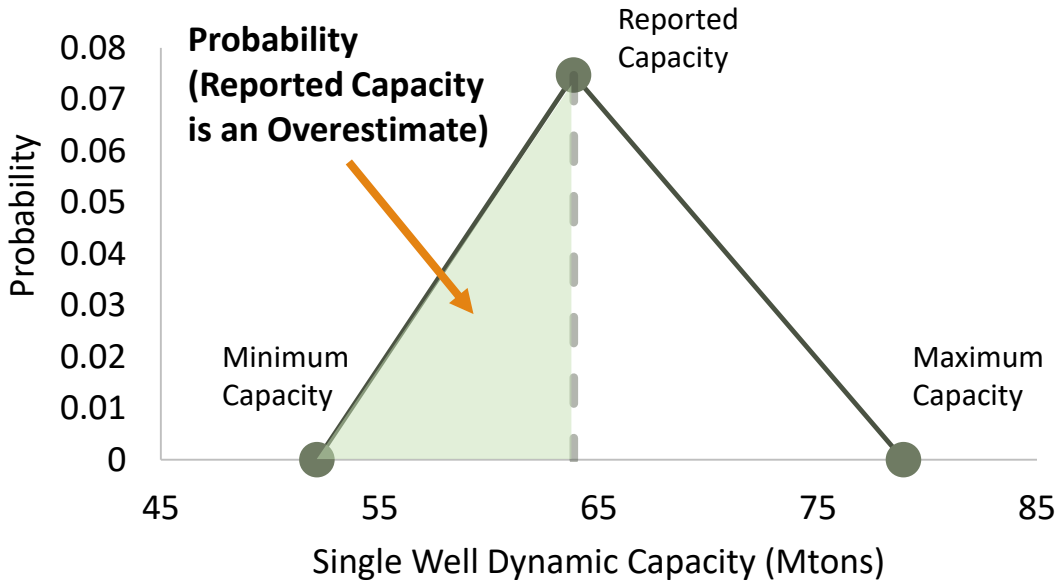
Dynamic Estimate

EASiTool Simulator

- Closed form analytical solution for capacity
- Considers pressure, reservoir properties, fluid properties
- Gives sensitivity analysis & multi-well capacity results



Uncertainty



Injectivity Risk

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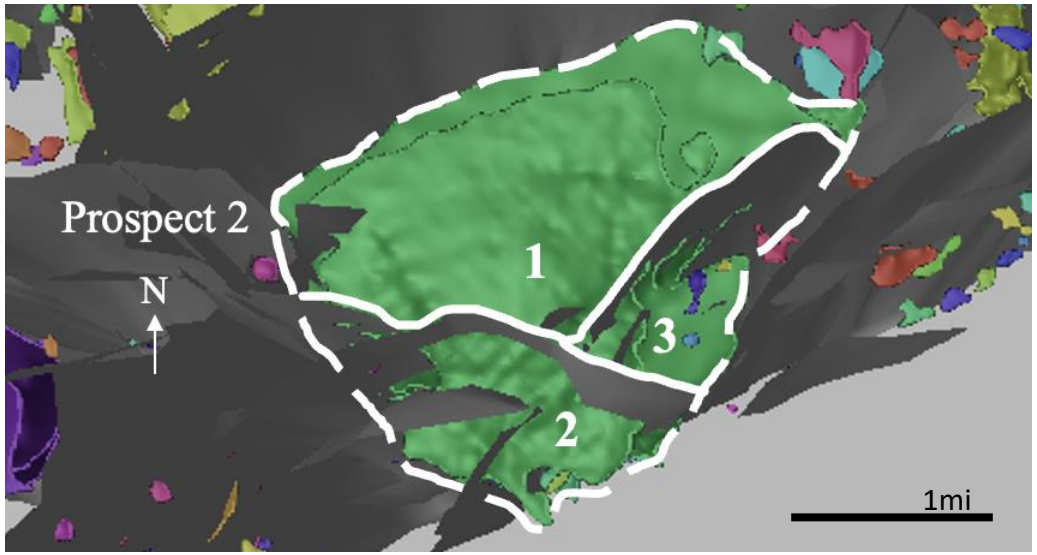
At what rate can the reservoir store CO_2?

- Reservoir Thickness
- Reservoir Permeability
- Reservoir Pressure
- Reservoir Continuity
  - Vertical: Net to Gross Ratio (NTG)
  - Lateral: Fault Compartmentalization

Risk Level	Thickness	Pressure	Continuity
	✓	✓	✓
	✓		✓
	✓		×
	✓	×	×
	×	×	×



Financial Risk

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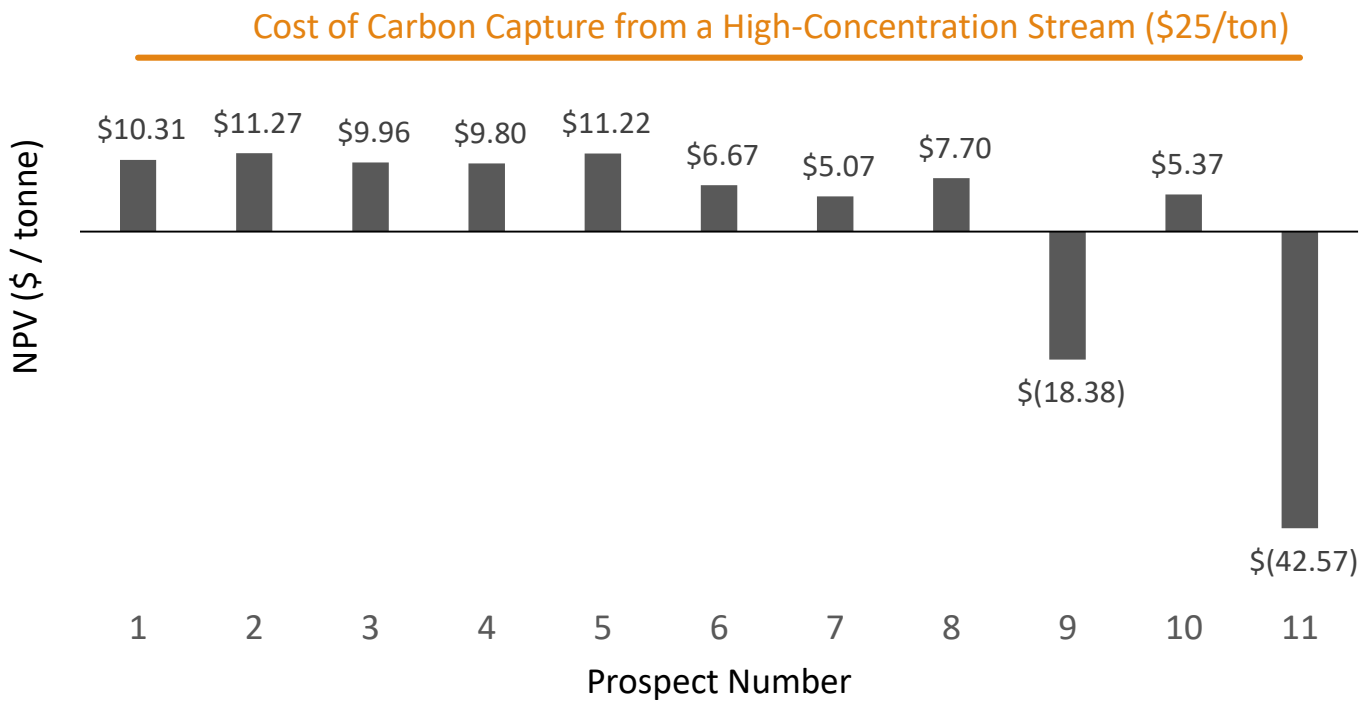
Prospect Differentiation

- Evaluate relative costs of sequestration between prospects
- Identify prospects to that are most likely to support upstream capture costs

Discounted Cash Flow Model Inputs

- Values sequestration portion of the projects
- Capacity & Injectivity estimates from EASiTool modelling
- Technical expenses from published sources
- Revenues based on current and potential future 45Q tax credit policies

Prospect Value ($ / ton)



* Values using $50/ton 45Q Credit Value

Ranking with CRS Maps

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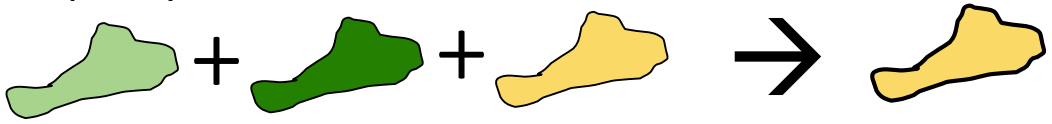
Composite Risk Segment (CRS) Mapping

- Adapted from a hydrocarbon industry ranking tool
- Flexible to incorporate any risk elements possible
- Intuitive, spatial display of risk
- Provides broad prospect differentiation

Overlaying Risk Colours

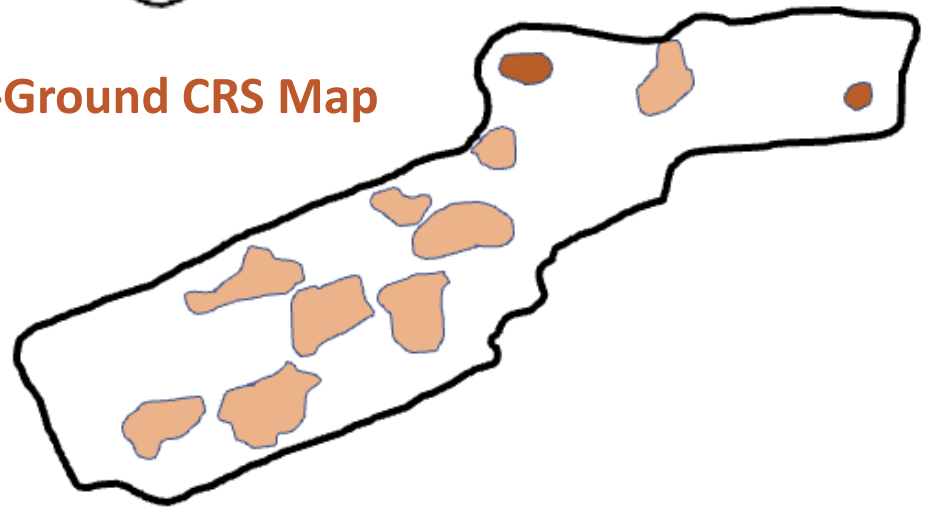
Capacity + Injectivity + Confinement → **Subsurface Risk**



Risk Level				
Lowest	Low	Average	High	Highest

Subsurface CRS Map

Above-Ground CRS Map



Ranking with EMV

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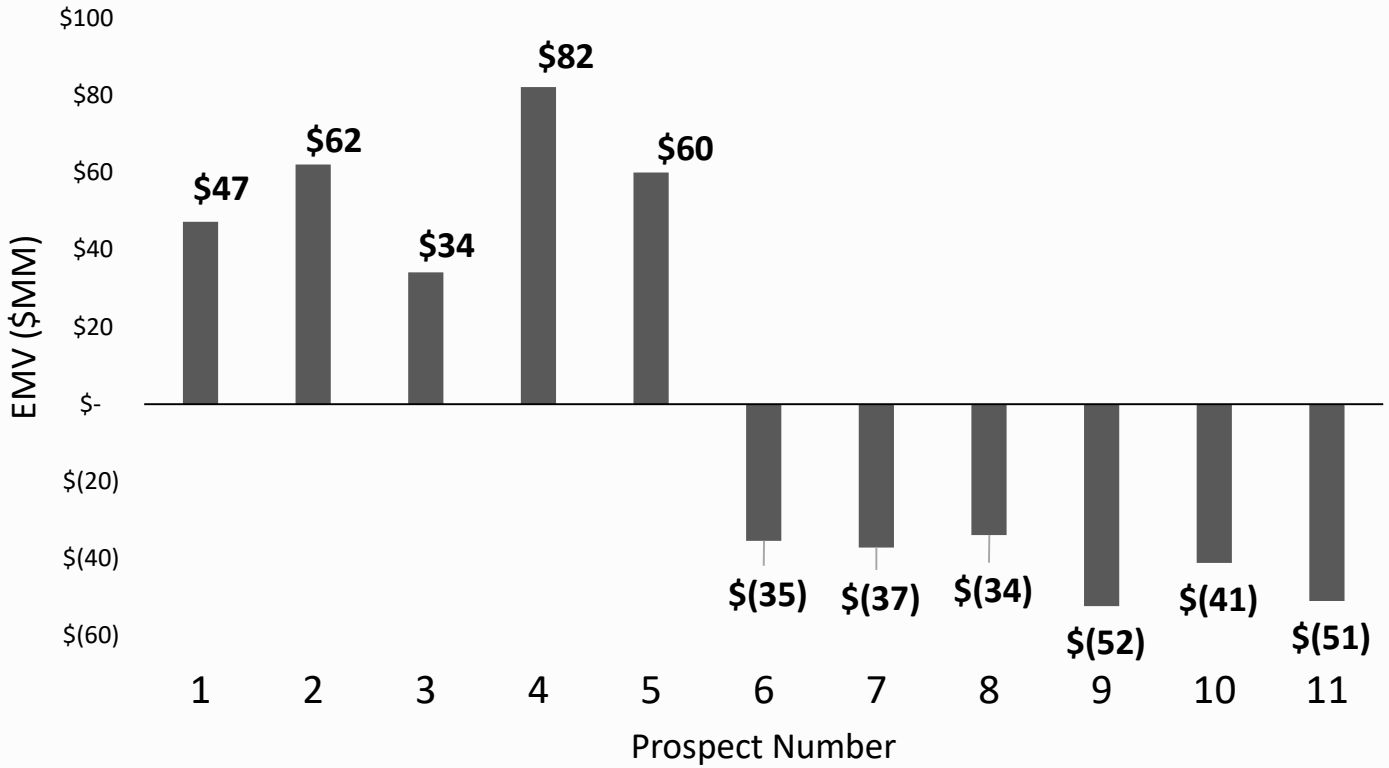
Estimated Monetary Value ($MM)

- Quantitative, risk-weighted measure of value
- Dependent on "Chance of Success" composite value of all geologic risk scores
- Allows for finer-scale prospect differentiation

Varying Chance of Success's Impact on Ranking



Conclusions

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Study Goals

- Improve TexLa prospect inventory using real geology
- Quantify geological and Above-Ground risk factors
- Identify prospects with the maximum probability of success

Study Conclusions

- Identified larger CCS opportunities with multi-reservoir potential within the TexLa Miocene section
- Risking workflow that is repeatable and based on commonly available data
- Ranking prospects focuses developers on highest-quality prospects

Acknowledgements

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Thank you to…

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- GCCC Researchers & EER Program for the academic and fellowship support
- Friends & Family for a wonderful two years!

NATIONAL ENERGY TECHNOLOGY LABORATORY

US DOE NETL

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Acknowledgements

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multidisciplinary studies for interdisciplinary solutions

Trap Risk

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Does the subsurface structure collect CO_2?

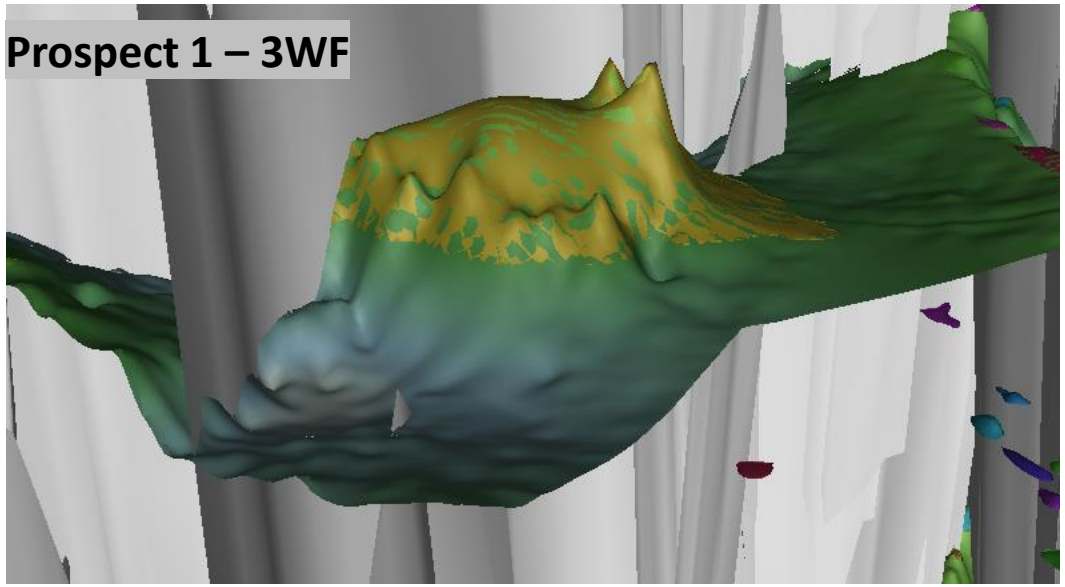
Trap Type Classification

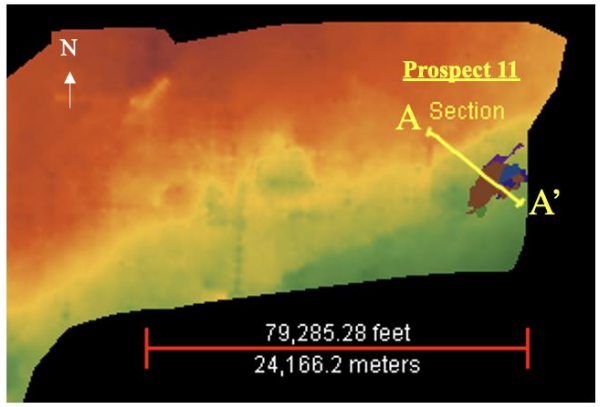
- 4 Way Dip (4WD)
- 3 Way Fault (3WF)

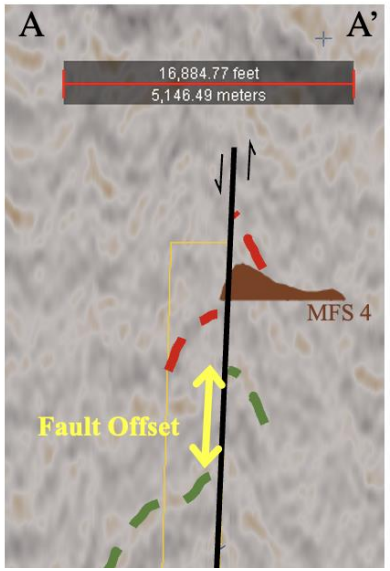
Determine fault offset : reservoir thickness ratio

- Offset : Thickness > 2
- Offset : Thickness ~ 2
- Offset : Thickness < 2

Prospect 1 – 3WF







Seismic data courtesy of SEI Inc.,
Interpretation belongs to the University of Texas at Austin

Seal Risk

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Does the lithology prevent the vertical migration of CO_2?

Intercepting Wells Production History

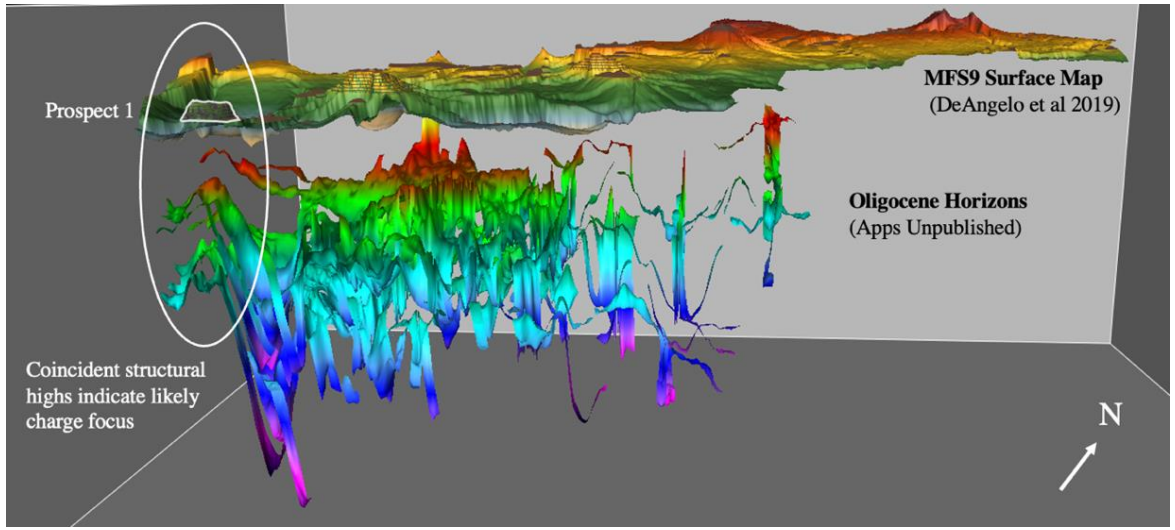
- Gas Field → Proven Gas Seal
- Oil Field → Proven Oil Seal
- Dry Wells → **Oligocene Charge Access Review**
  - Unlikely Charge
  - Likely Charged

Well Summary Report

42245031240000

General Information Header

Country:	UNITED STATES
Final Status:	OIL PRODUCER
Drill Total Depth	8,600 FT
Log Total Depth:	
True Vertical Depth:	
Current Operator:	KINGWOOD EXPLORATION LLC



Well Leak Risk

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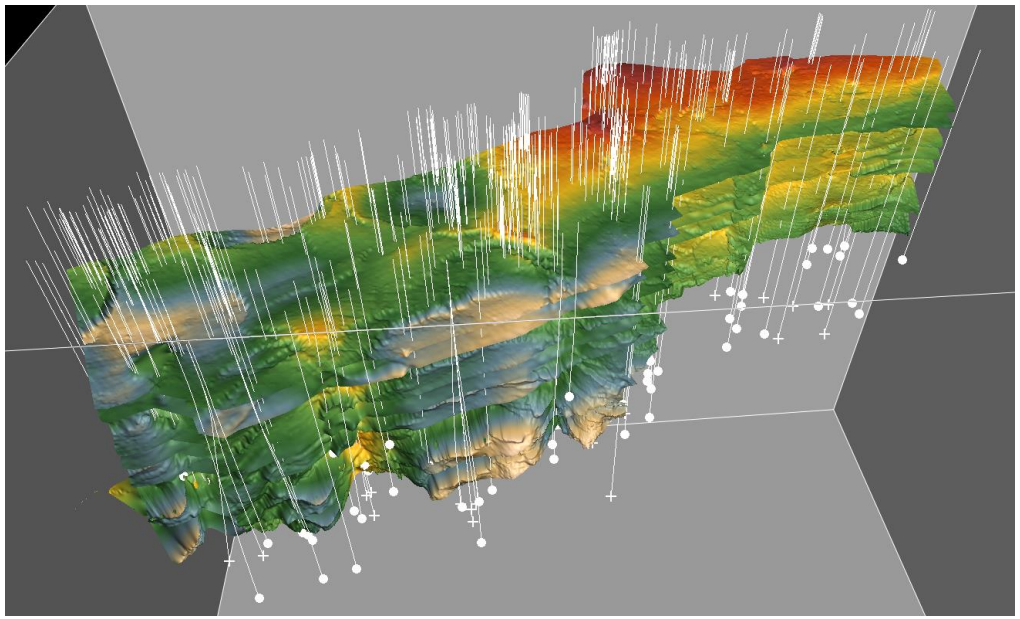
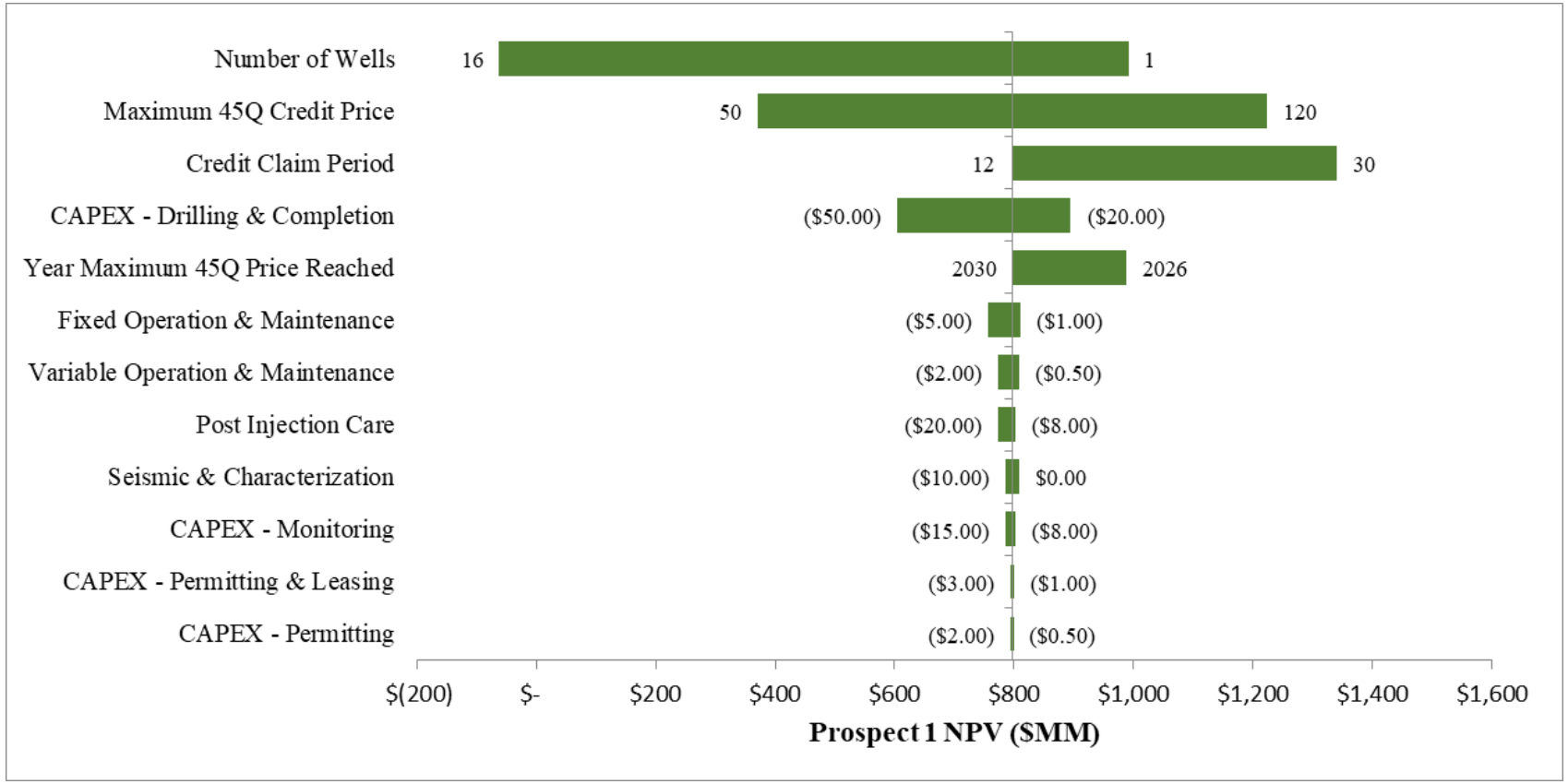
Has the Gulf's hydrocarbon exploration history impacted a prospect's ability to hold CO_2?

Wells & Well Age

- Modern Wells, Observed < Expected
- Modern Wells, Reported ~ Expected
- Modern Wells, Reported Wells > Expected
- Pre-1967 wells present
- Pre-1935 wells present



Financial Risk



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Meckel, T.A., Treviño, R., Carr, D., Nicholson, A., Wallace, K., 2013, Offshore CCS in the northern Gulf of Mexico and the significance of regional structural compartmentalization: Energy Procedia, v. 37, p. 4526 – 4532, doi: 10.1016/j.egypro.2013.06.359

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