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MIOCENE OFFSHORE CO_2 STORAGE RESOURCES

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Task 2. Offshore Storage Resource Estimation
Task 3. Risk Assessment, Simulation, and Modeling

Partnership for carbon capture & offshore geologic storage GoMCarb
GCCC Gulf Coast Carbon Center
Bureau of Economic Geology
NETL National Energy Technology Laboratory

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Presentation Outline

- Problem statement
- Goals
- Methods
- Current results
- Summary

Problem Statement

We have achieved significant progress in assessing CO_2 storage capacity in terms of **how fast** CO_2 can be injected as well as **how much** CO_2 can be injected before it will spill out of the storage complex.

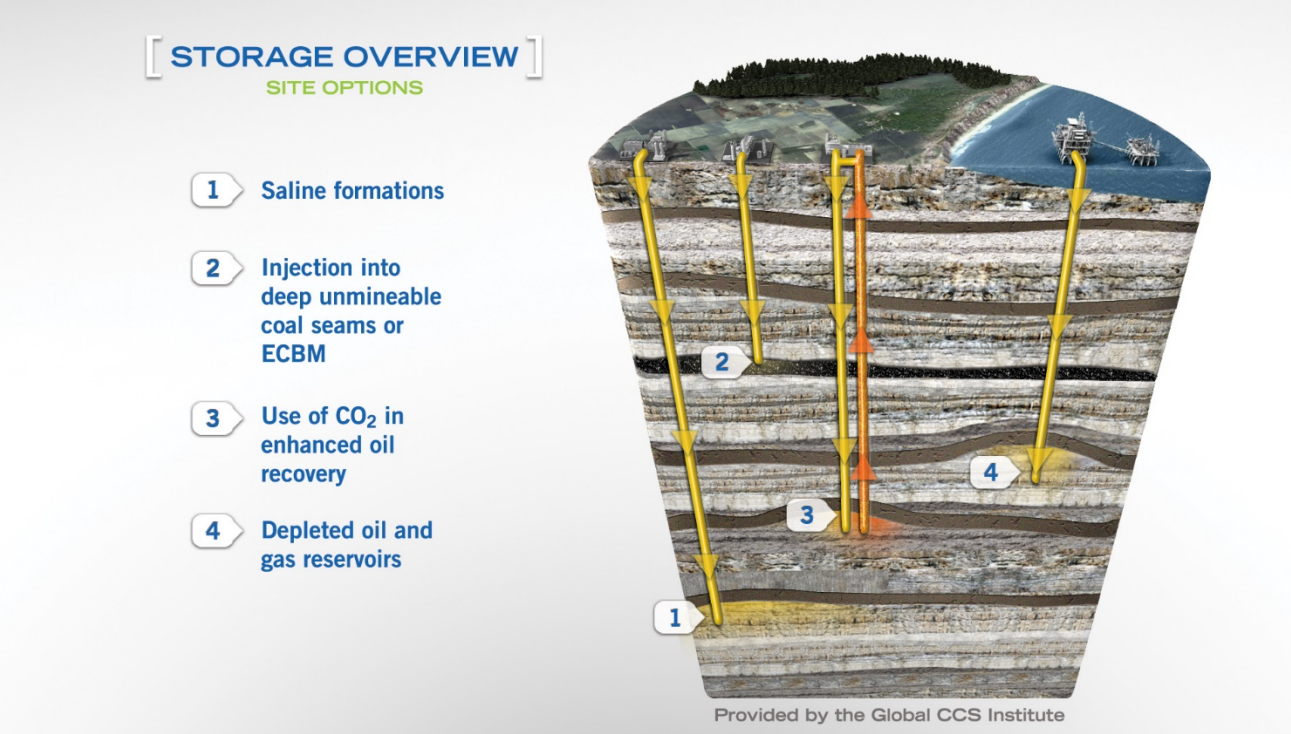
From this work we have come to identify **a number of factors** which have **strong impacts on capacity** which need in-depth assessment.

To prepare for large-scale injections with **many sites in the same basin**, both **onshore and offshore**, advances in our understanding are necessary in areas such as:

- **Characterization** of the geological formations
- Assumptions about how **CO_2 migration** paths access pore volumes
- Impacts of **pressure change** in zones displaced by **faults**
- **Basin-scale** pressure **interference** and vertical-lateral **propagation**
- **Pressure boundaries** that compartmentalize or isolate injected fluids and pressure response

Goals

- Using **extensive** and **comprehensive characterization methods** to **increase confidence** and **reduce risk** in siting CO_2 storage with very large volume within a basin
- Applying the understanding to one or more important basins



Methods

Assessment will focus on the Gulf of Mexico (onshore and offshore) with a vision to apply these concept broadly:

- Conduct detailed **geologic characterization** and numerical & earth **modelling** at site- and basin-scale, using extensive & comprehensive subsurface data set, augmented by literature and global collaboration
- Use **sequence stratigraphy** and **depositional systems** as tools for understanding CO_2 migration and pressure propagation at basin scale, consider further relationships of trapping mechanisms (structural or capillary trapping etc.) to static and dynamic capacity
- Assess the impact of **structural** and **tectonic** components on fluid flow and capacity; compartmentalization, connectivity, and geo-mechanical impacts; impact of regional fault system e.g. between onshore and offshore Miocene
- Consider how **petroleum systems** analysis and concepts can inform CCS
- Evaluate and apply **resource quantification methods** at project-scale, beginning with SPE CO_2 Storage Resources Management System (SRMS)

Methods

1 Sequence Stratigraphy and Depositional Systems Analysis

2 Tectonic and Structural Analysis

3 Petroleum System Analogue

Static

4 Characterization

5 Geo-cellular Modeling

6 Numerical Modeling

7 Reservoir Simulation

Dynamic

8 CO_2 Storage Resources Classification (SRMS)

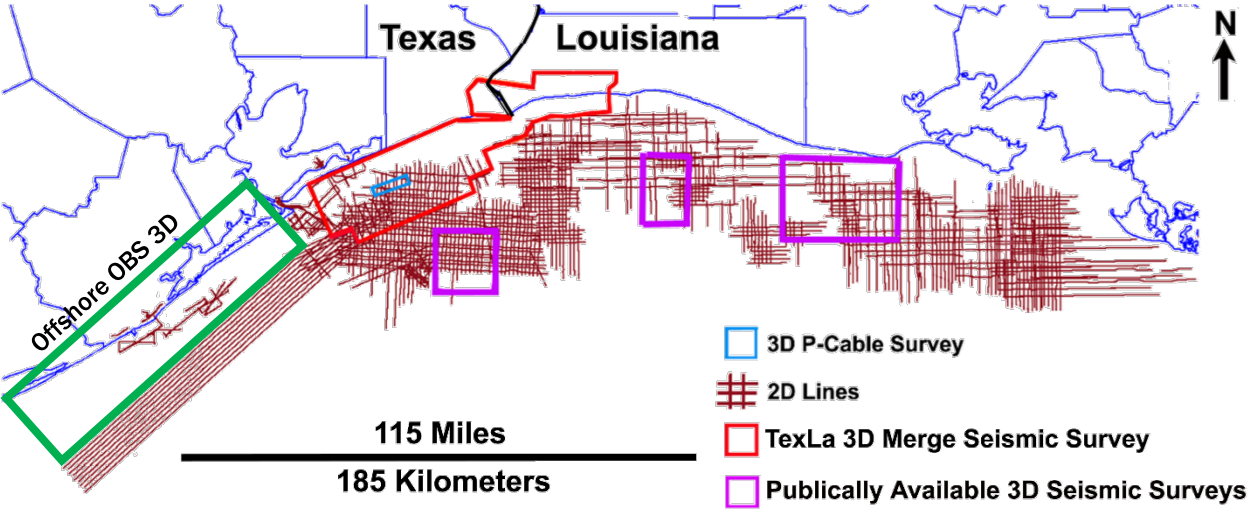
9 Literatures

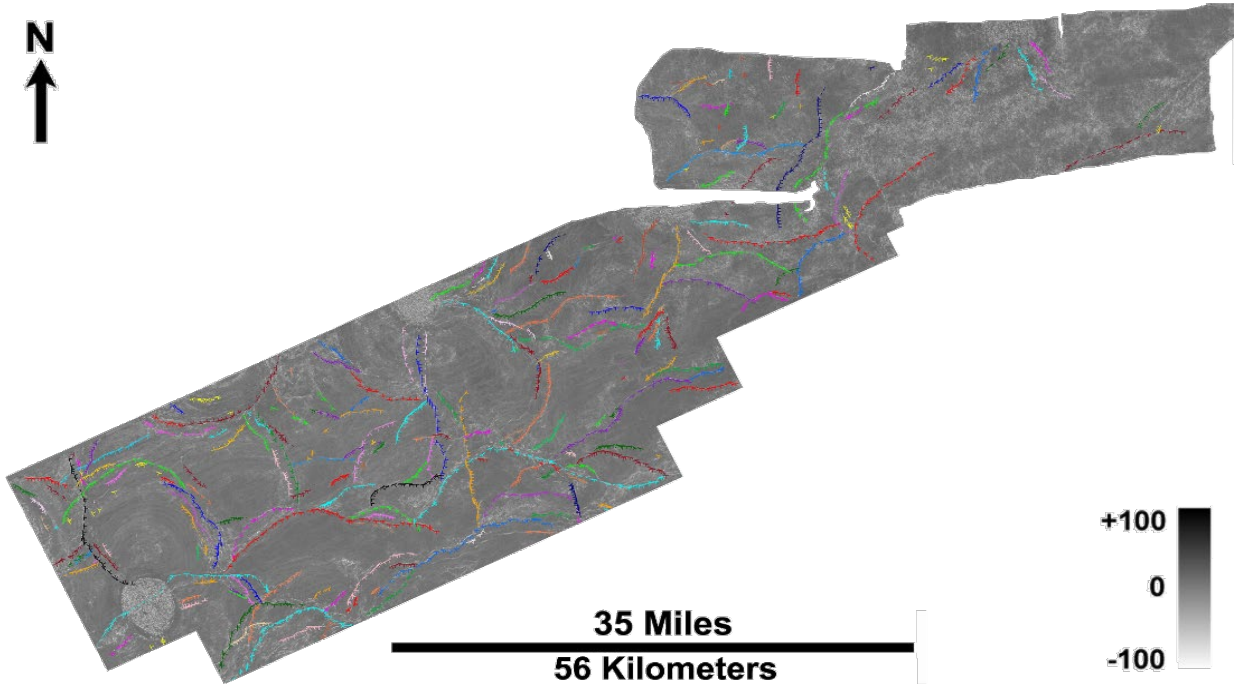
10 Global Collaboration

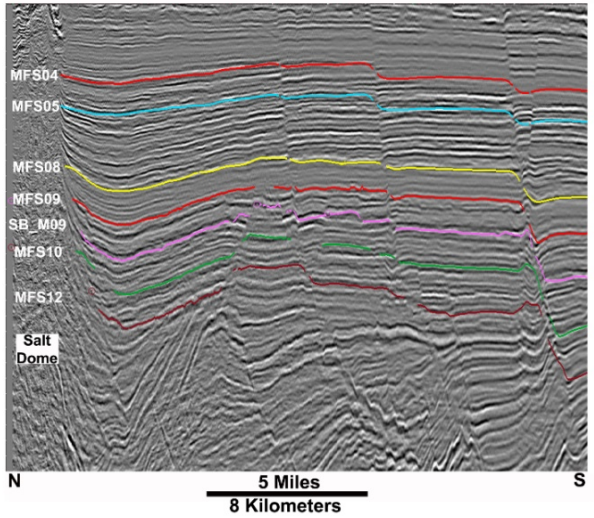
Augmentation

Current results

- Seismic-based regional assessment (DeAngelo et al, 2019)
- Volumetric-based CO_2 storage resources assessments of 10-L site “trap layers” (Fifariz, Postdoctoral fellow, in DeAngelo et al, 2019)
- High Island 24-L and 10-L sites characterization and geo-cellular modeling (Ruiz and Ramirez-Garcia, MS students)
- Log prediction using multi-attribute transforms and neural network (Feng, Postdoctoral fellow)
- Predicting CO2 plume migration using machine learning (Zhong, Postdoctoral fellow







Results:

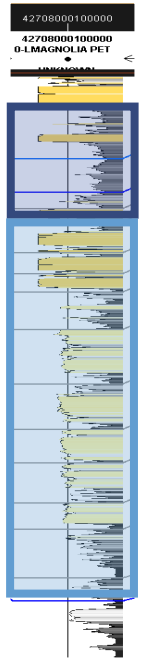
- 292 faults
- 7 horizons (SS-based, Maximum Flooding Surfaces-MFS and Sequence Boundary-SB)
- 7 time structure maps
- 7 depth structure maps
- Velocity models
- Seismic attributes (semblance, RMS amplitude, isopach, etc.)

Regional Seismic-based Assessment

Published in IJGGC, Feb 2019 issue

DeAngelo et al. (2019)

Generalized Stratigraphic Column (Offshore TX)



Middle Miocene

Lower Miocene

MFS04/05

Deltaic sand reservoirs (?)

MFS08

Amph-B shale

Structural/stratigraphic/combination traps

MFS09

Deltaic sand reservoirs

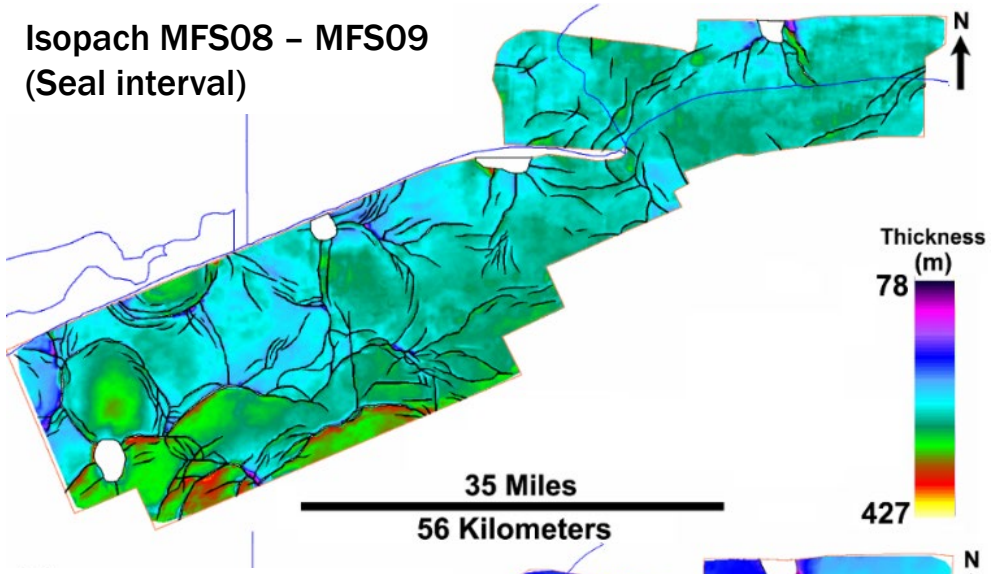
Deltaic sand reservoirs

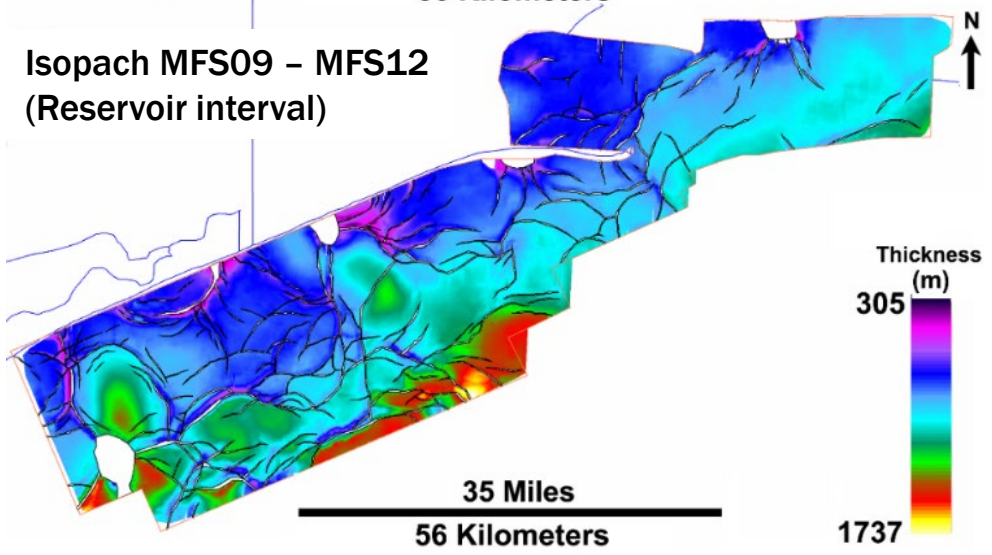
MFS10

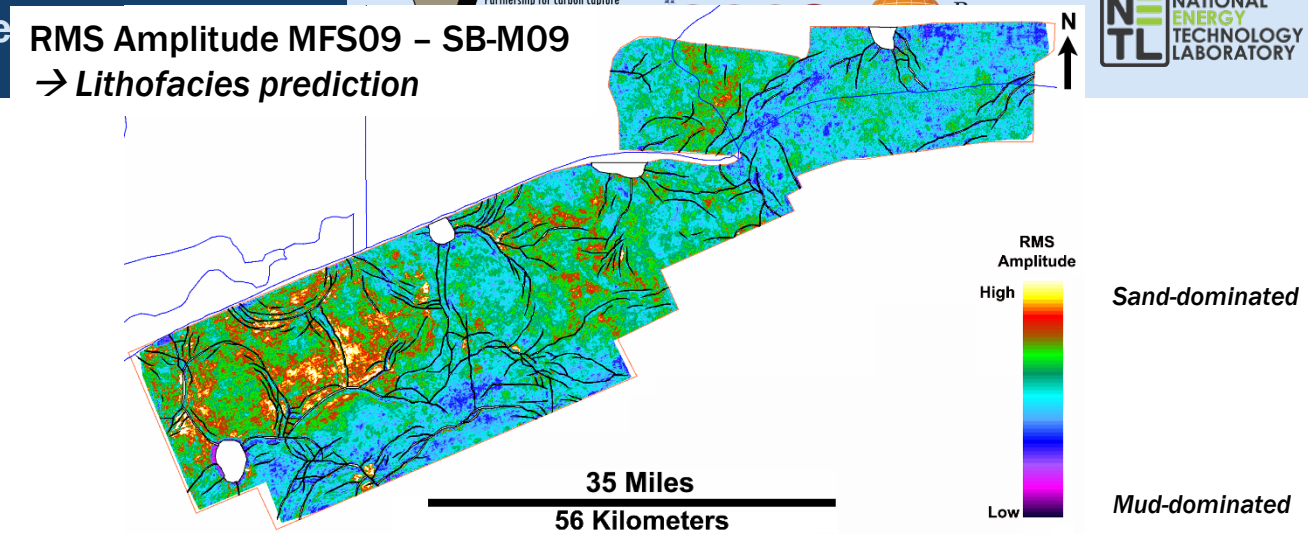
Regional Seal

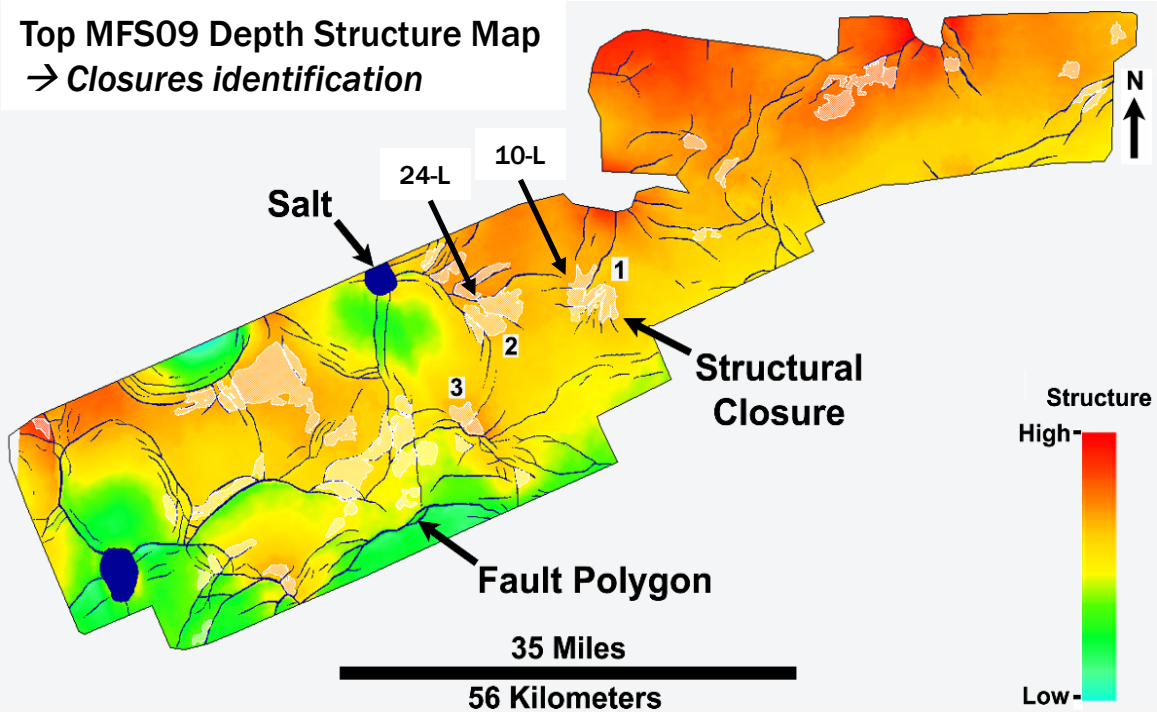
Reservoir interval: 5,000 – 7,500 ft (1,500 m – 2,300 m) Approx. 750+ m thick of aggradational sst

MFS picks on TXLA area based on Iulia Olariu's work
Based on Dave Carr's work in the south (Offshore OBS)





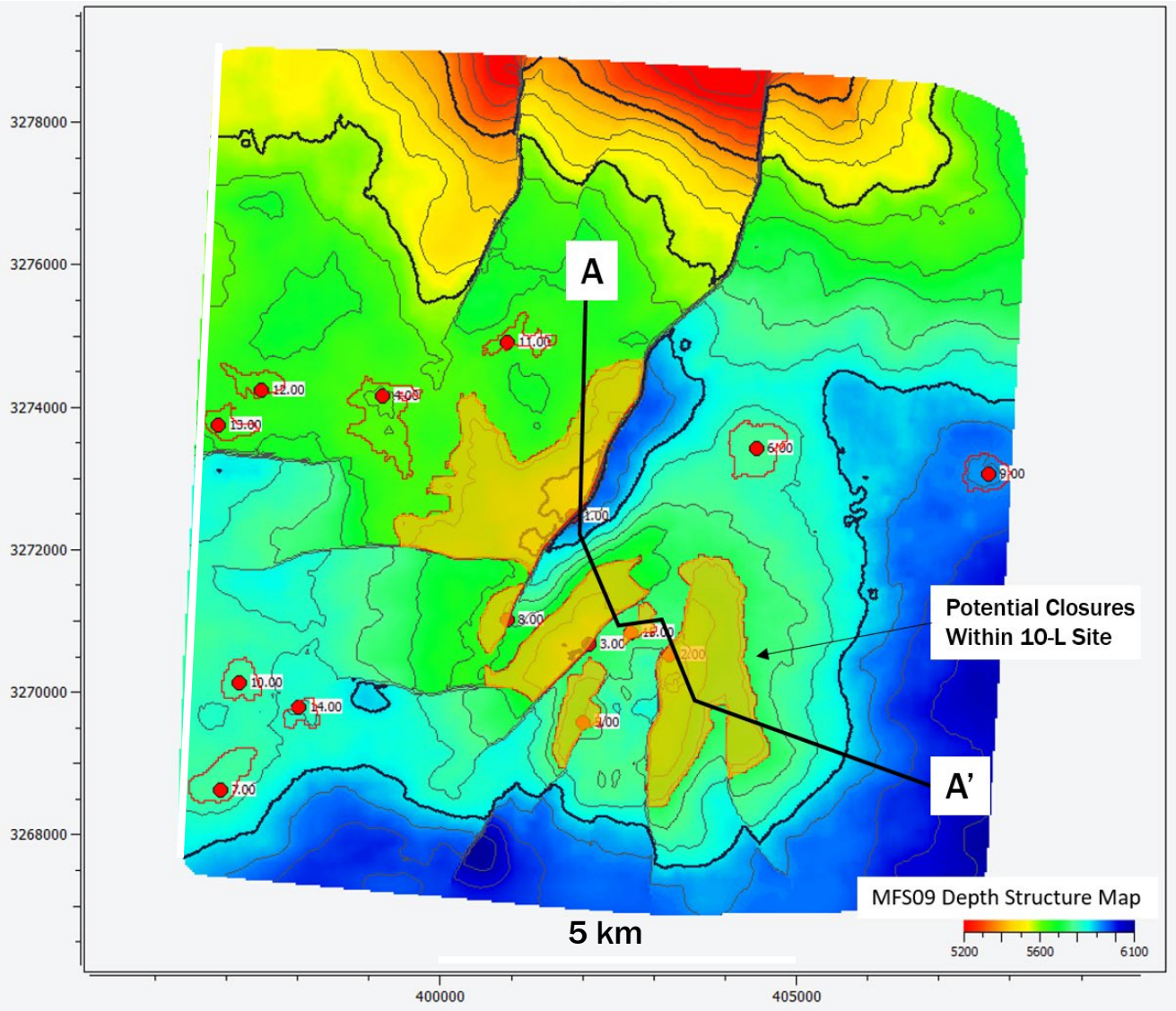


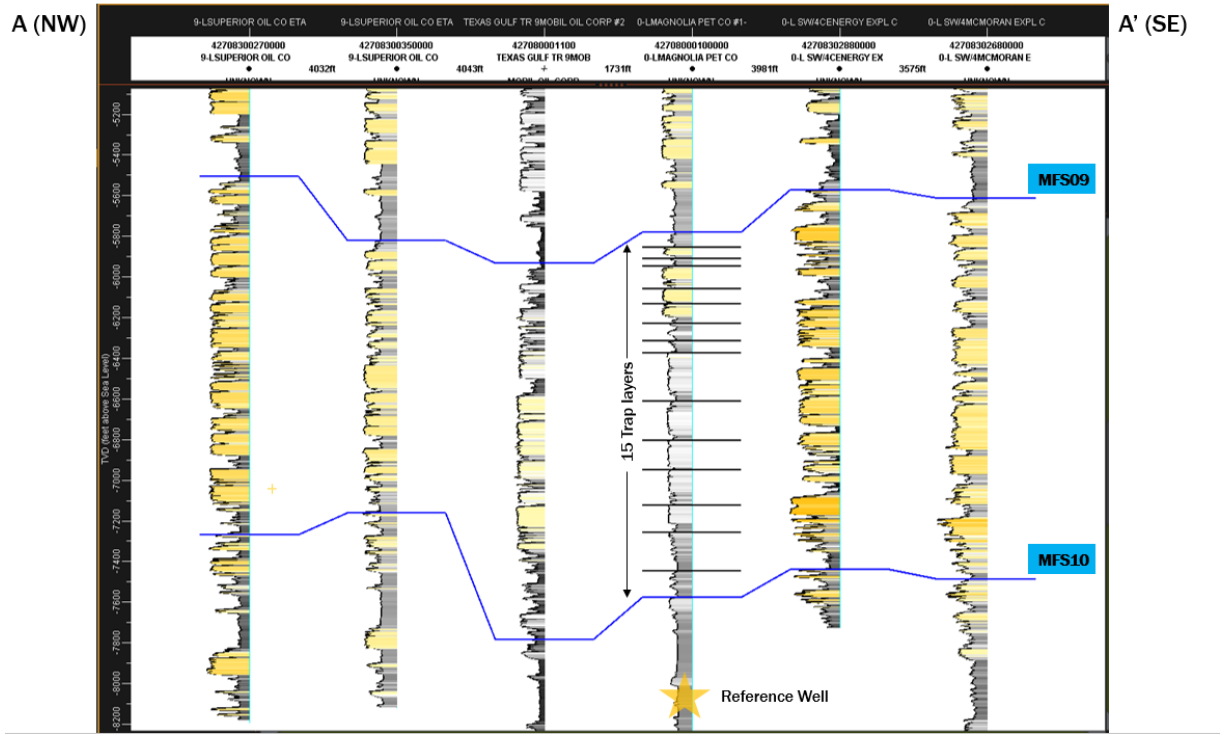


Regional Seismic-based Assessment

*Structural closures were identified on the **depth structure map*** of the top reservoir interval or bottom regional seal (MFS09)

DeAngelo et al. (2019)



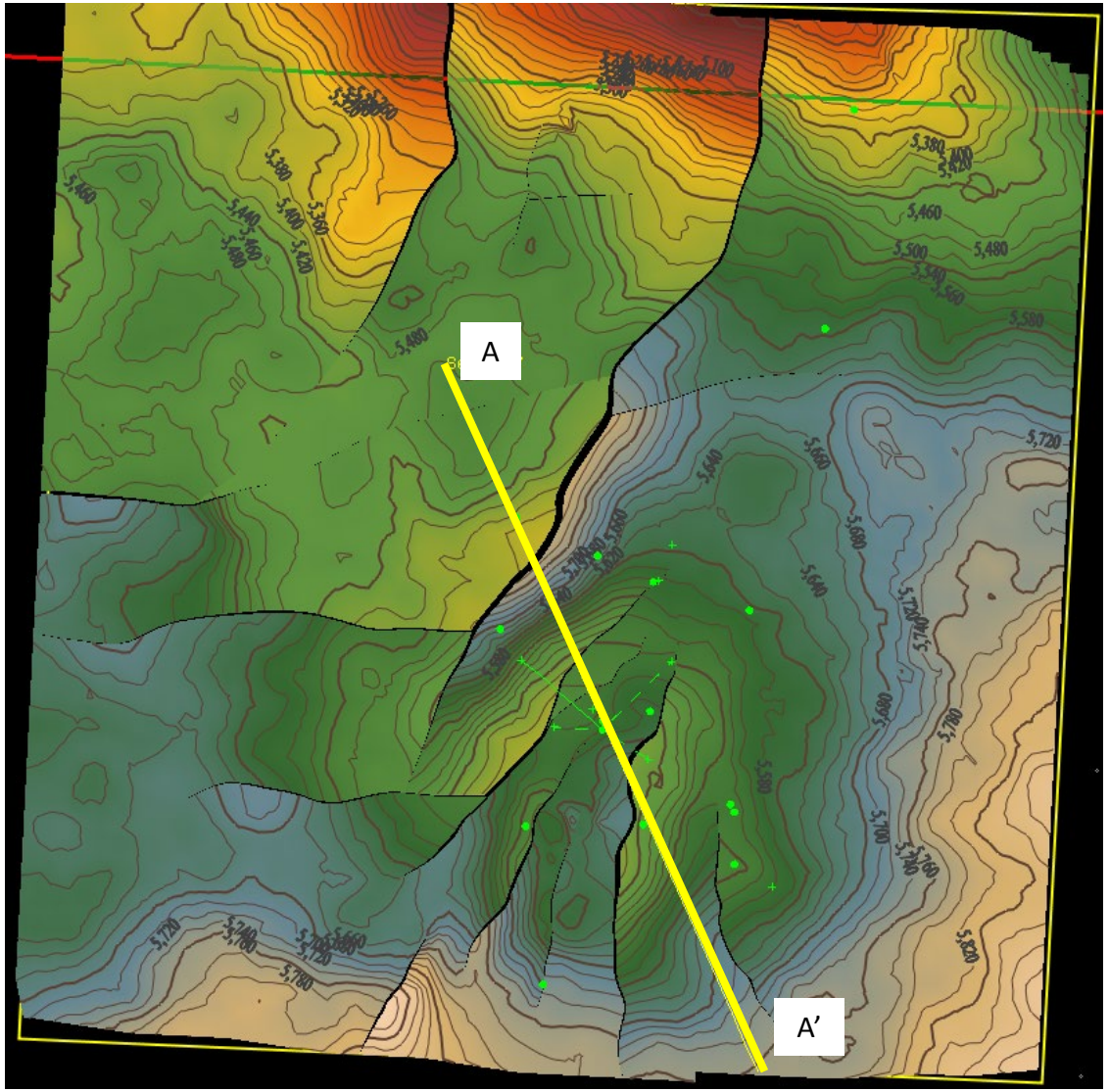


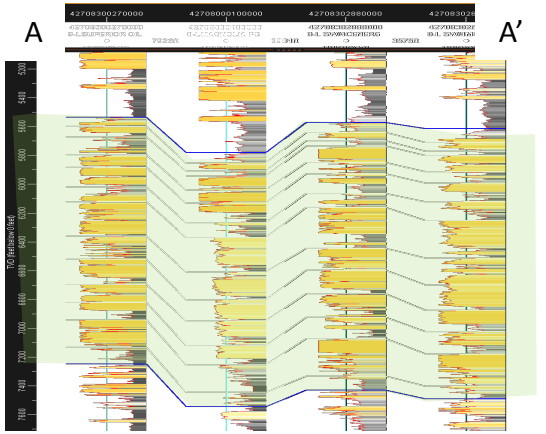
*CO_2 storage resources estimate for 10-L site trap layers based on this volumetric-based method is approximately **50 MT CO_2***

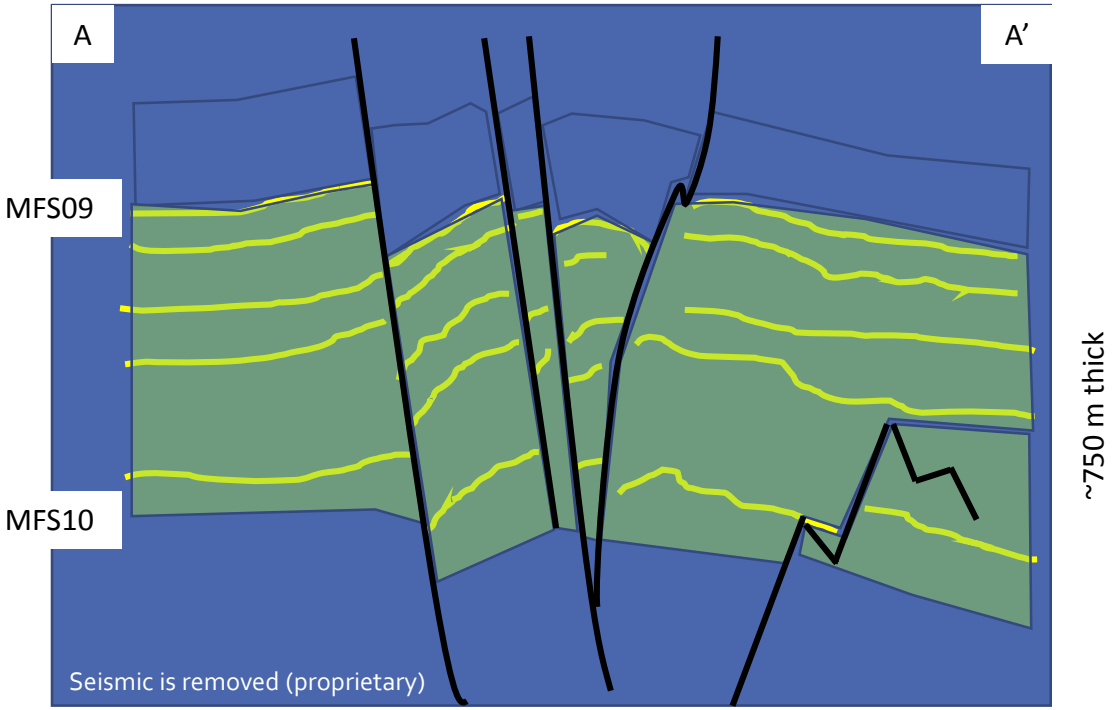
CO_2 storage resources estimation of 10-L site trap layers (**stacked storage**)

Fifariz (Postdoctoral Fellow) *in* DeAngelo et al. (2019)

Area of investigation: 11.3 x 11.4 km (7 x 7 mi)



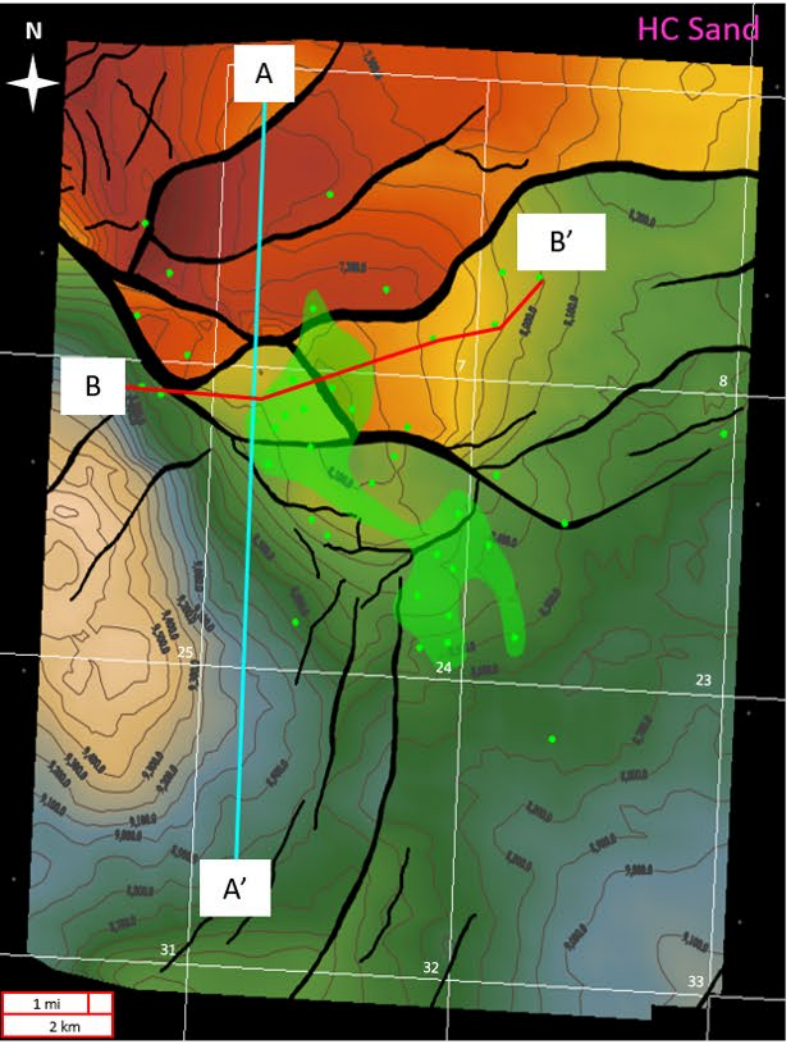


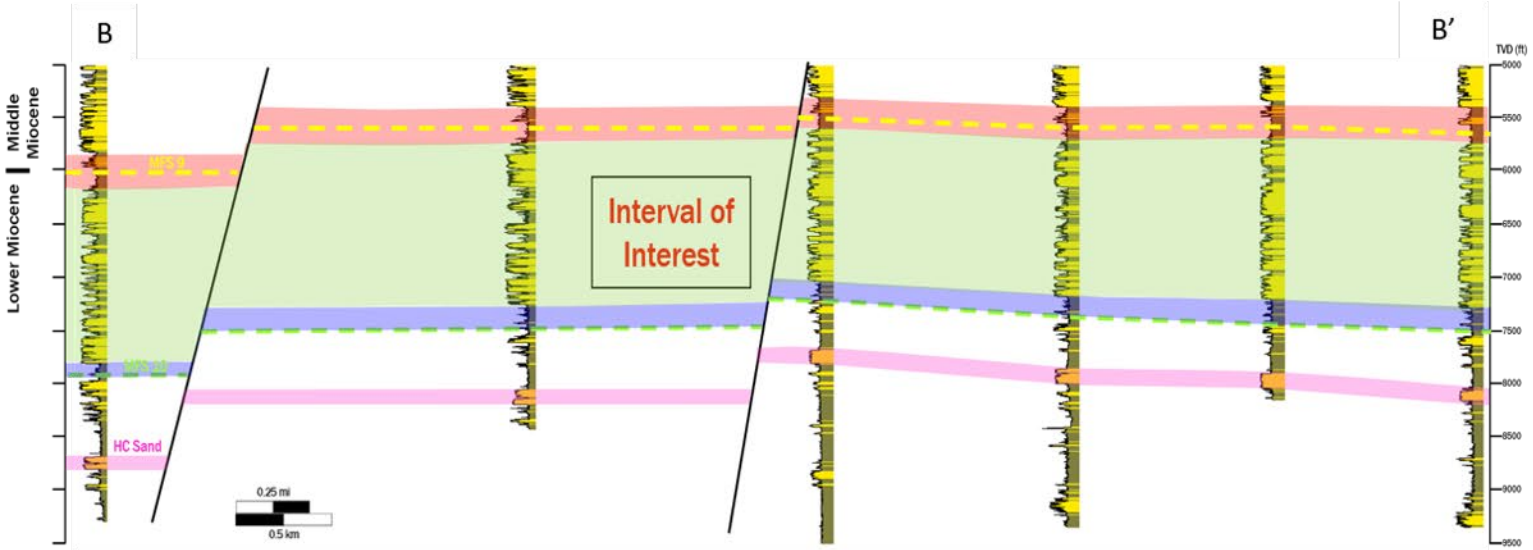


High-Island Block 10-L Site Characterization

Omar Ramirez-Garcia (M.S. Student)

Area of investigation: 14.5 x 12 km (9 x 7.5 mi)



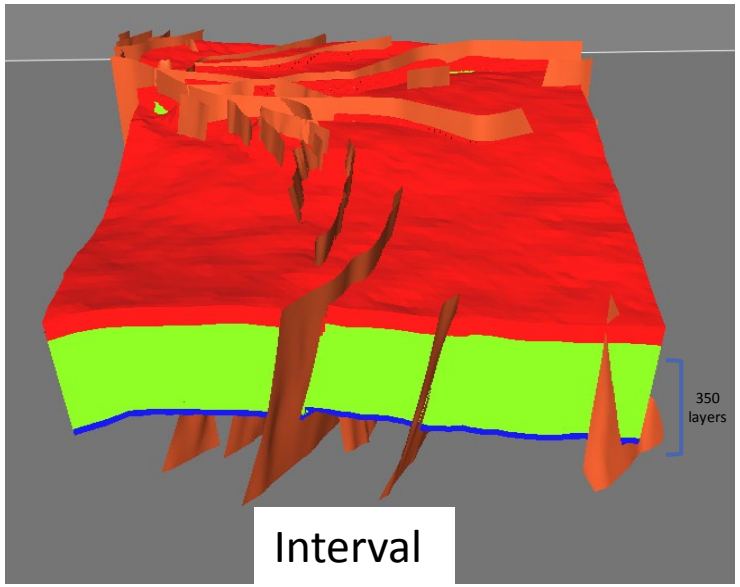


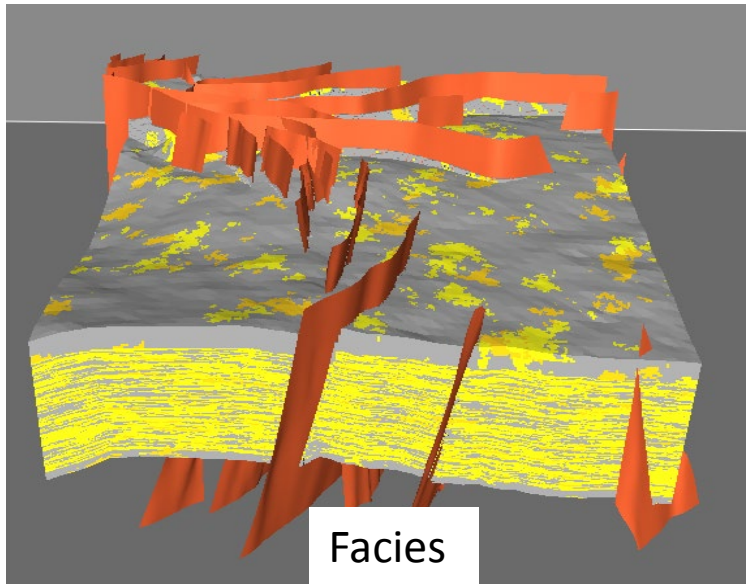
High-Island Block 24-L Site Characterization

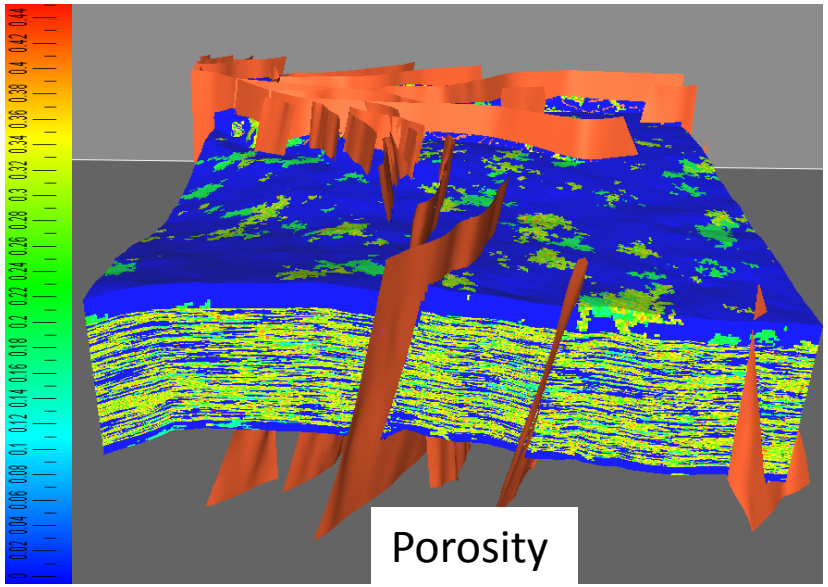
Izaak Ruiz (M.S. Student)

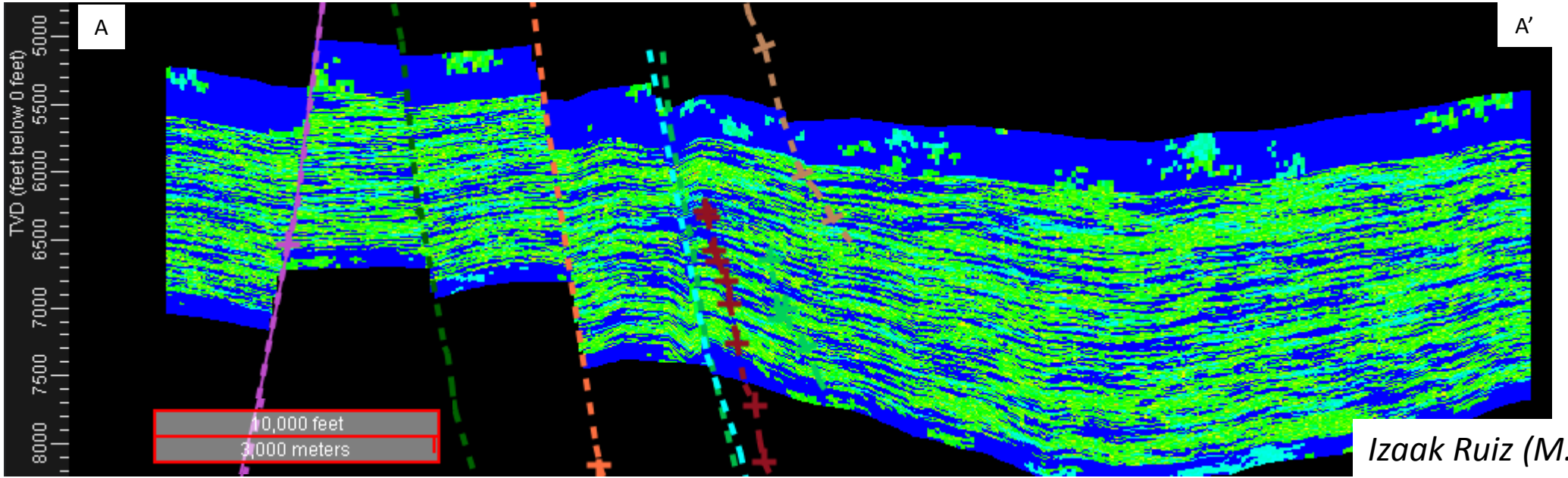
High-Island Block 24-L Geo-cellular Modeling

3D Grid = 14.5 x 12 km (9 x 7.5 mi)

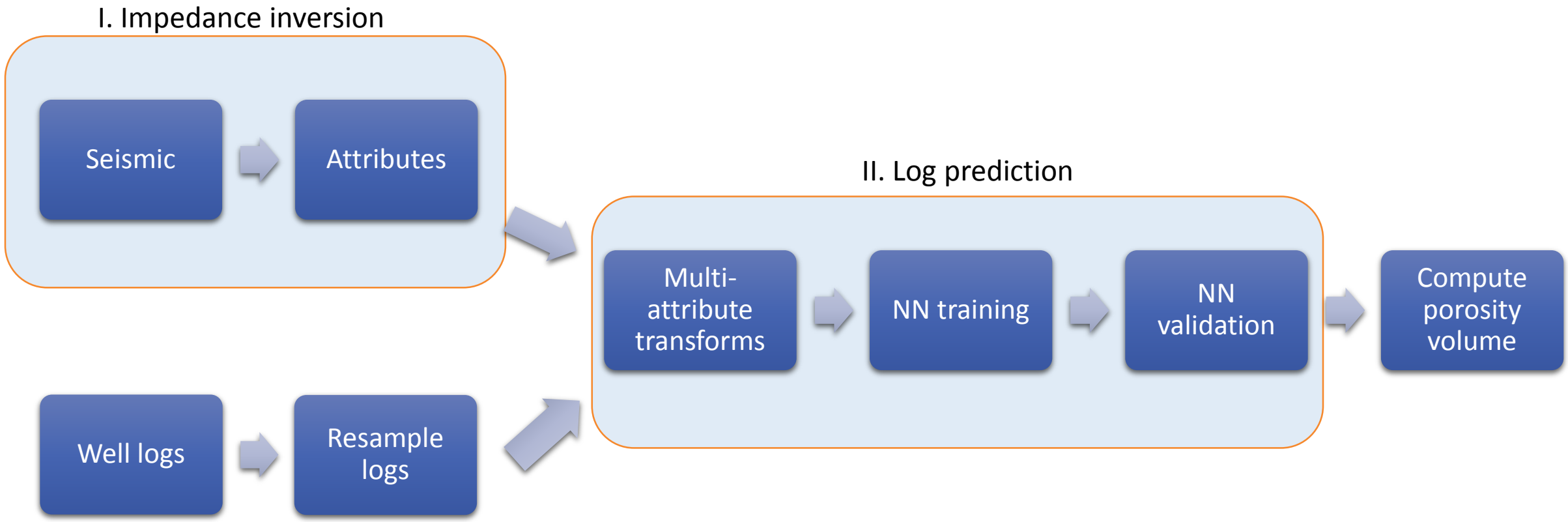








Izaak Ruiz (M.S. Student)



Log prediction using Neural Network Workflow

Ye Feng (Post-doctoral Fellow)

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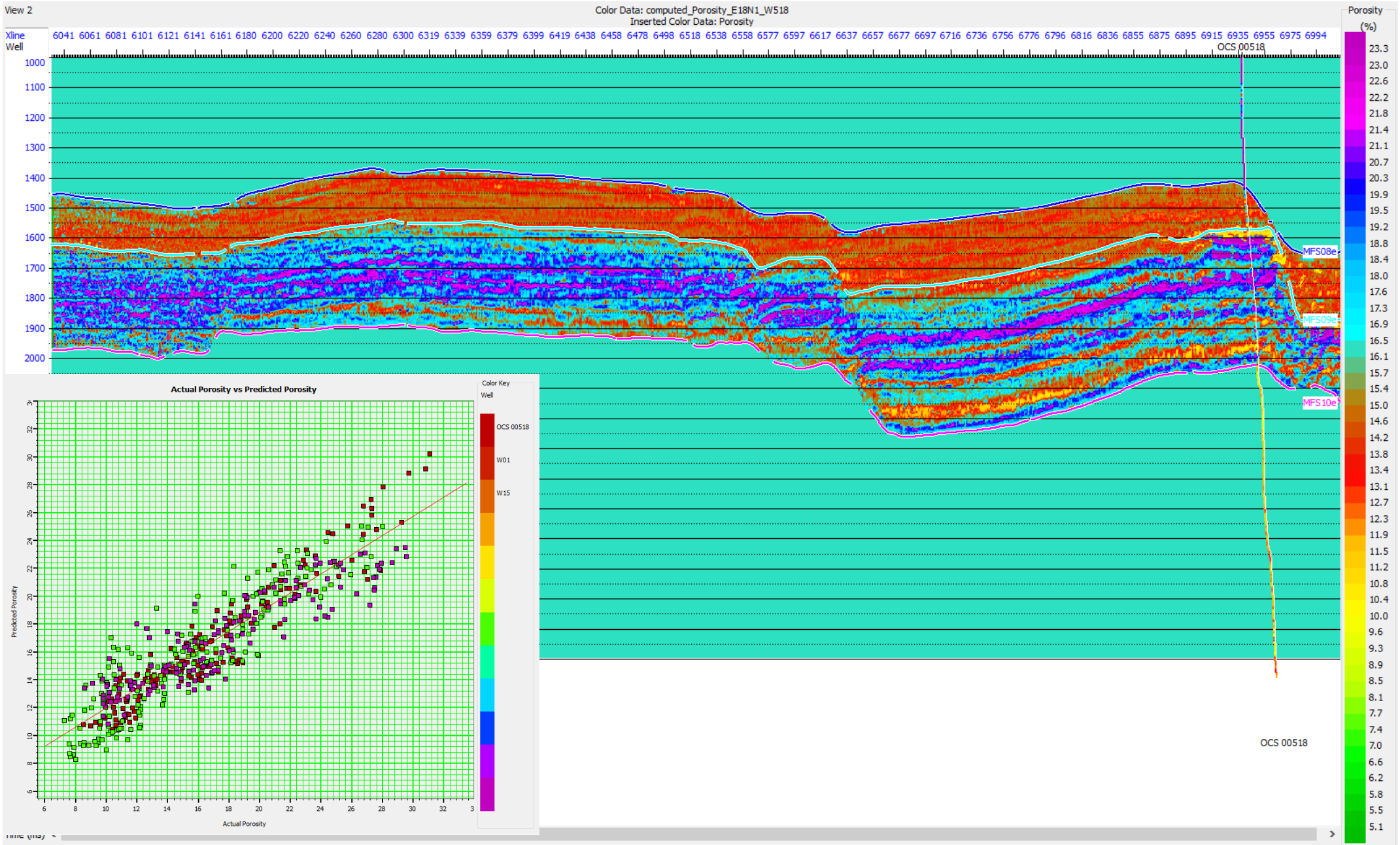

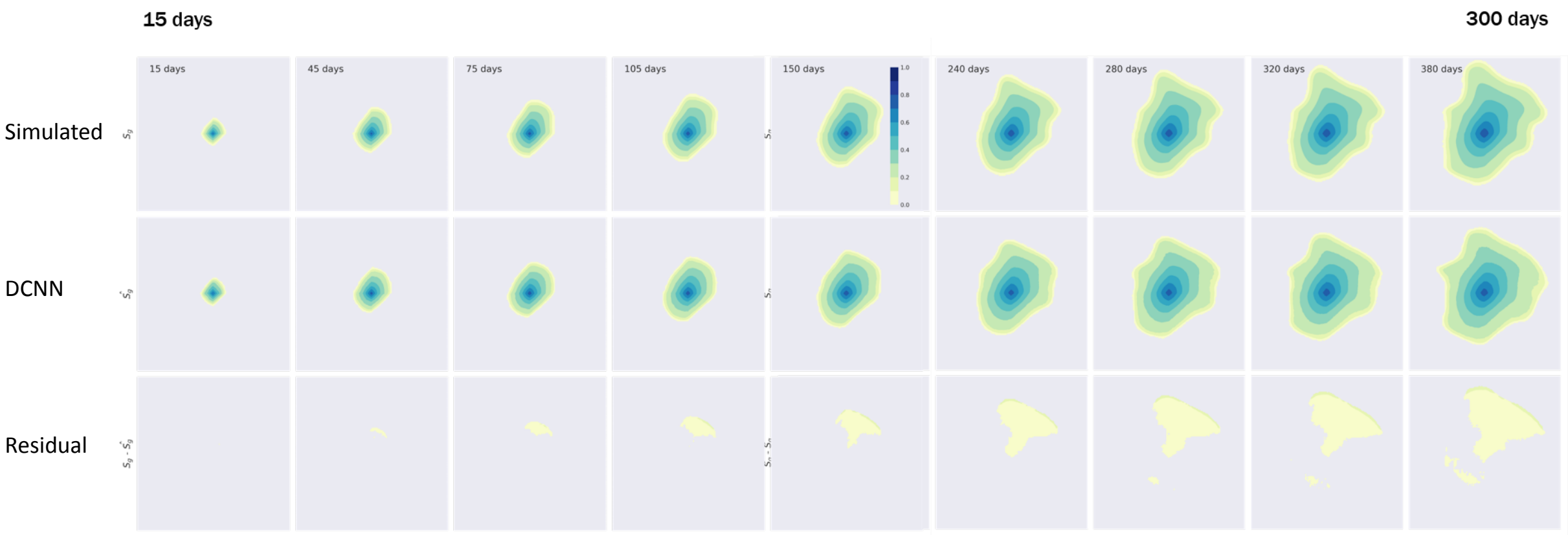

Input: Reservoir Properties-Permeability

Network: Deep Convolutional Neural Network

Output: CO_2 saturation (CO_2 Plume)

Advantages:

- High Accuracy: This network have high accuracy for CO_2 saturation prediction
- Cost effective: Predict the CO_2 saturation within very short time (~1 seconds)

CO_2 plume prediction based on machine learning

Zhong & Sun (*Under Review*: Water Resource Research)

Summary

Current results include progress in:

- Using large set of 3-D seismic data for regional seismic-based CO_2 sequestration assessment
- Estimating volumetric potential of trap layers (stacked storage) in aggradational sandstone package
- Conducting detailed characterization of storage sites within a complex
- Conducting geo-cellular modelling based on detailed reservoir characterization
- Using multi-attribute transforms and neural-network as a tool to predict porosity distribution within interval of interest
- Using machine learning to predict CO_2 migration

→ Future work:

- Basin-scale regional earth modeling
- PaleoScan geo-modeling and seismic-based stratal slicing
- Regional petroleum system analysis, collaboration with GBDS

References

DeAngelo, M. V., Fifariz, R., Meckel, T., & Treviño, R. H. (2019). A seismic-based CO2-sequestration regional assessment of the Miocene section, northern Gulf of Mexico, Texas and Louisiana. International Journal of Greenhouse Gas Control, 81, 29-37.

THANK YOU