De-risking Top Seal for CCS

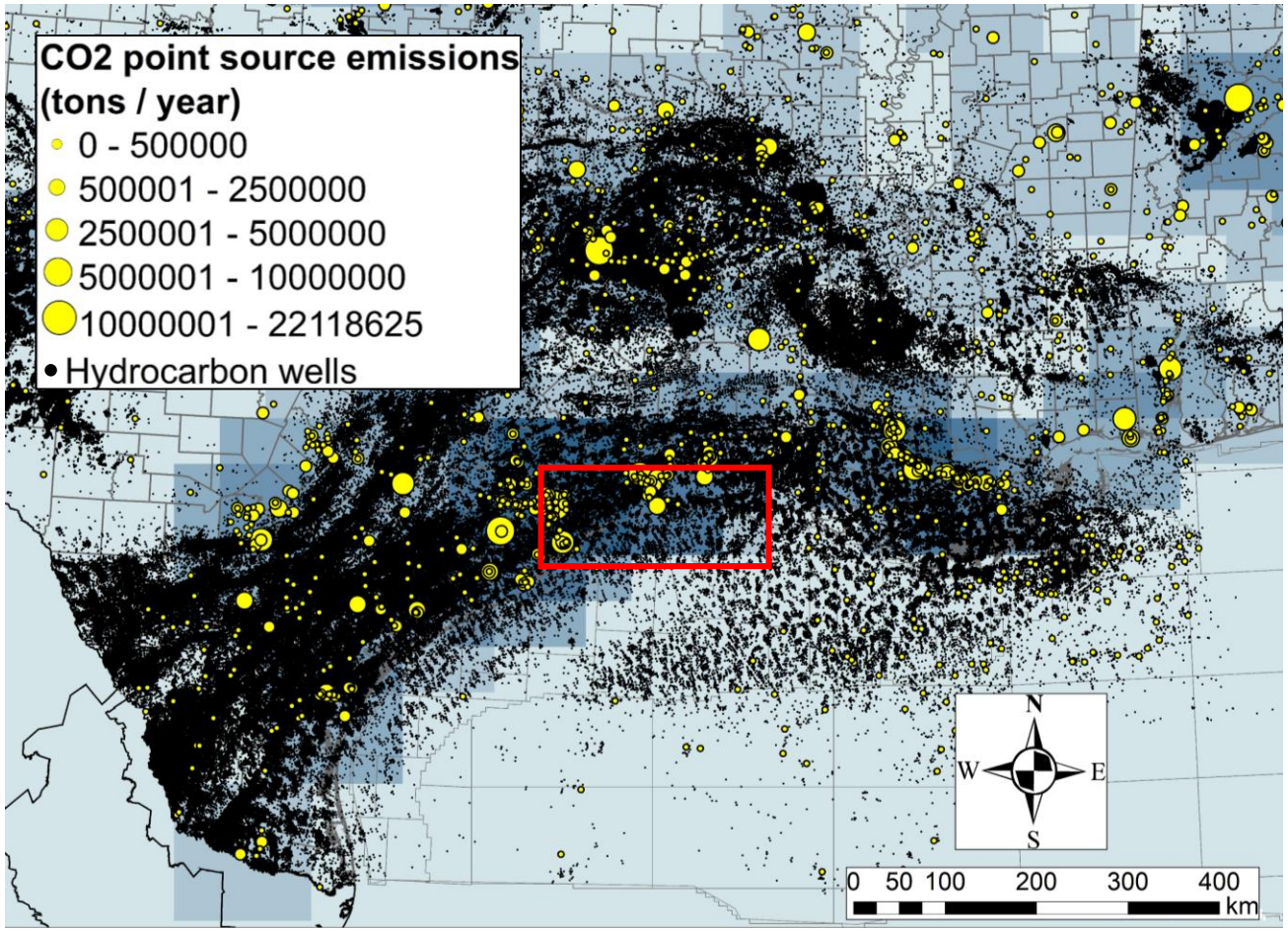
Alexander P. Bump, *Gulf Coast Carbon Center, BEG*

Gillian M. Apps, *Applied Geodynamics Laboratory, BEG*

Frank J. Peel, *Applied Geodynamics Laboratory, BEG*

Bureau of Economic Geology

Offshore



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

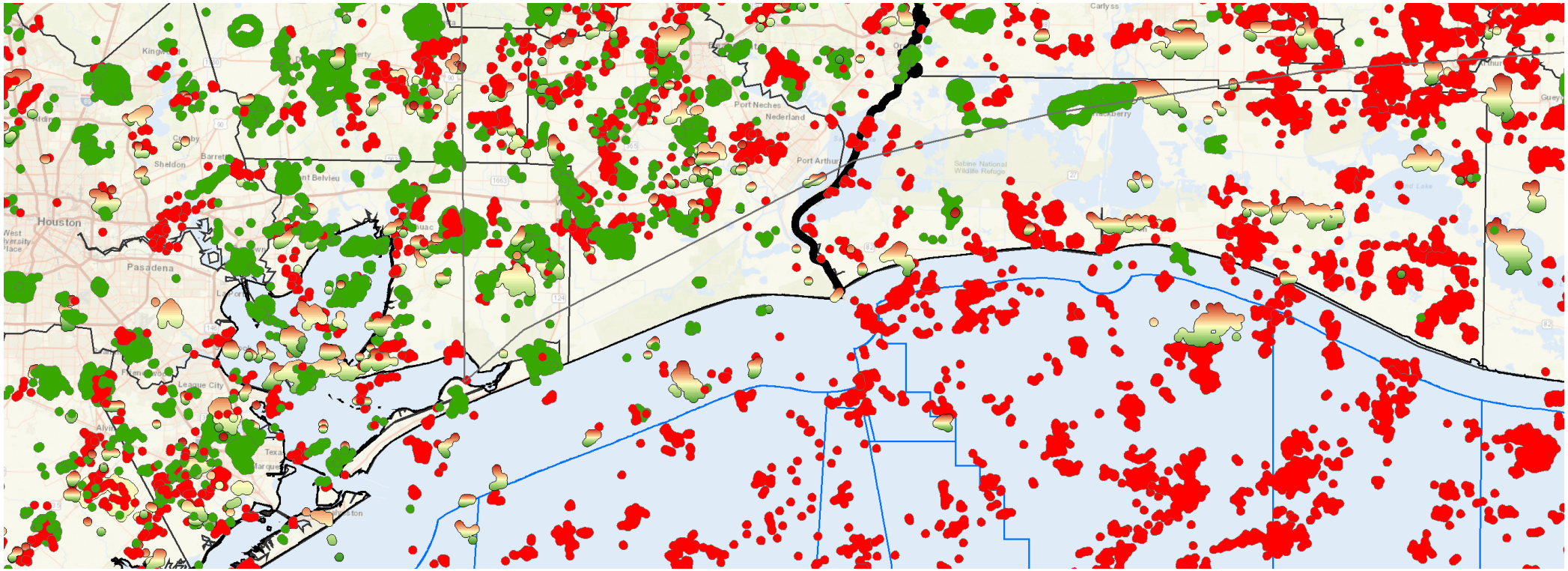
- Offshore GoM is highly prospective for CO2 storage
  - Close to major coastal emissions
  - Abundant subsurface data
  - Proven reservoirs and seals
  - Potentially re-usable infrastructure
- Advantages over onshore
  - Single landowner
  - Relatively few wells
  - Relatively few competing uses
  - Relatively modern infrastructure

GCCC GULF COAST CARBON CENTER

BUREAU OF ECONOMIC GEOLOGY

Upper Texas Coast

Producing Hydrocarbon Fields

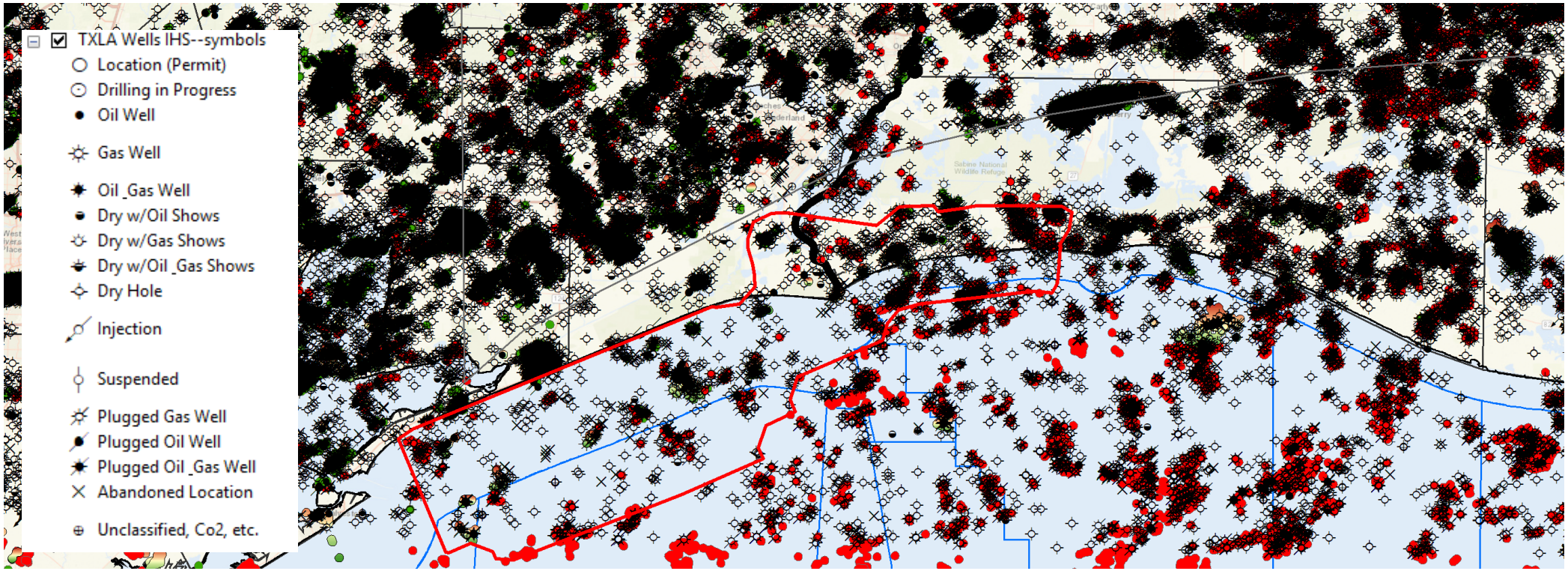


IHS Enerdeq, 2022

GCCC GULF COAST CARBON CENTER

BUREAU OF ECONOMIC GEOLOGY

A Worrying Number of Dry Holes



IHS Enerdeq, 2022

Implications for Seal Risk

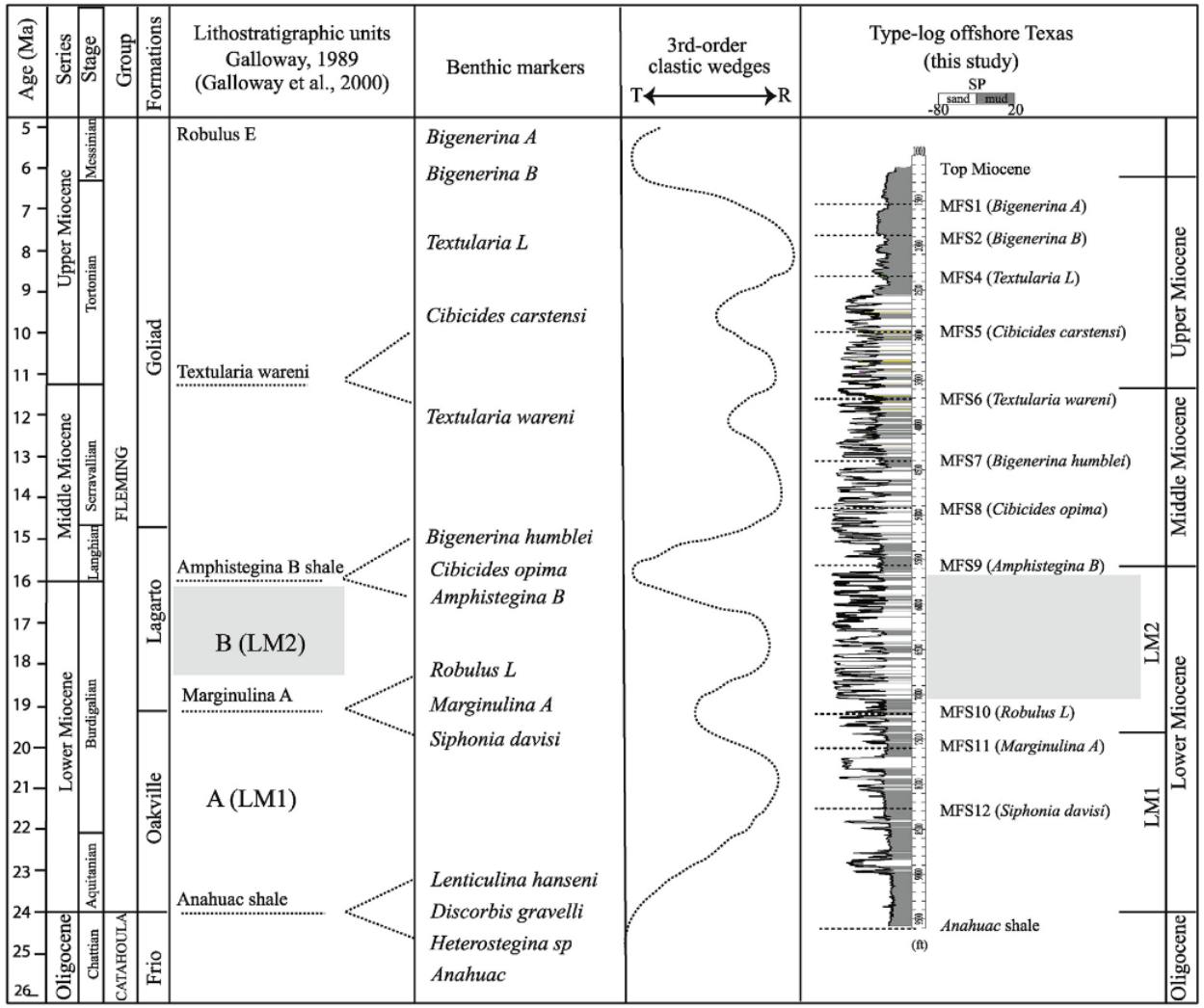
A CO_2 prospect that does not contain hydrocarbons remains at risk for seal and maybe trap.
The absence of hydrocarbons could be:

- evidence that the trap &/or seal failed
- evidence it never received a hydrocarbon charge

Unless you can show it should not have received a charge, the absence of charge increases the trap &/or seal risk (Bayesian update)

Therefore, if we can show the trap never received a hydrocarbon charge, we can eliminate this Bayesian update and reduce the trap &/or seal risk

Offshore Texas Miocene Stratigraphy

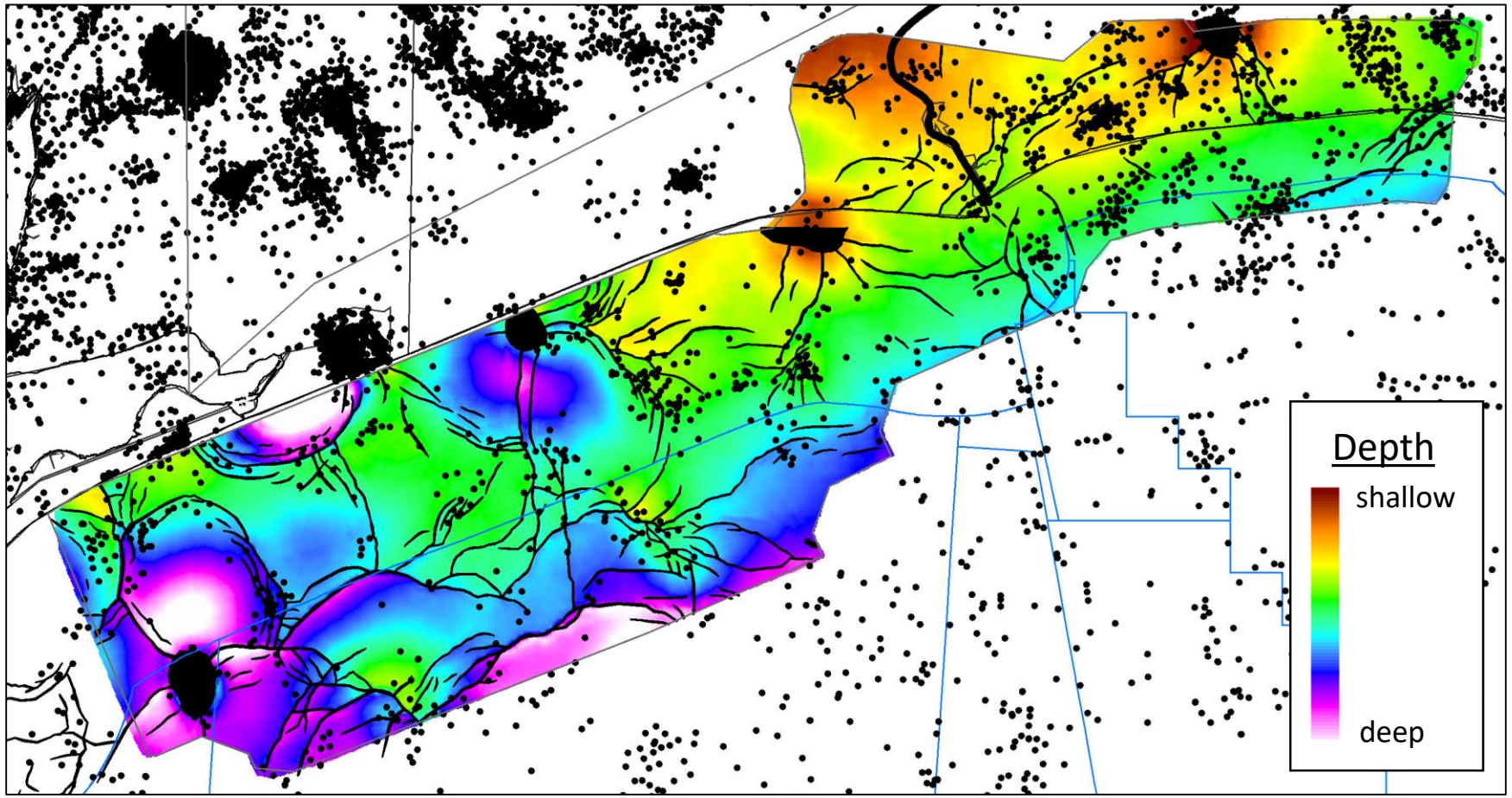


Olariu et al, 2019

GCCC GULF COAST CARBON CENTER

BUREAU OF ECONOMIC GEOLOGY

Lower Miocene Structure, All Wells

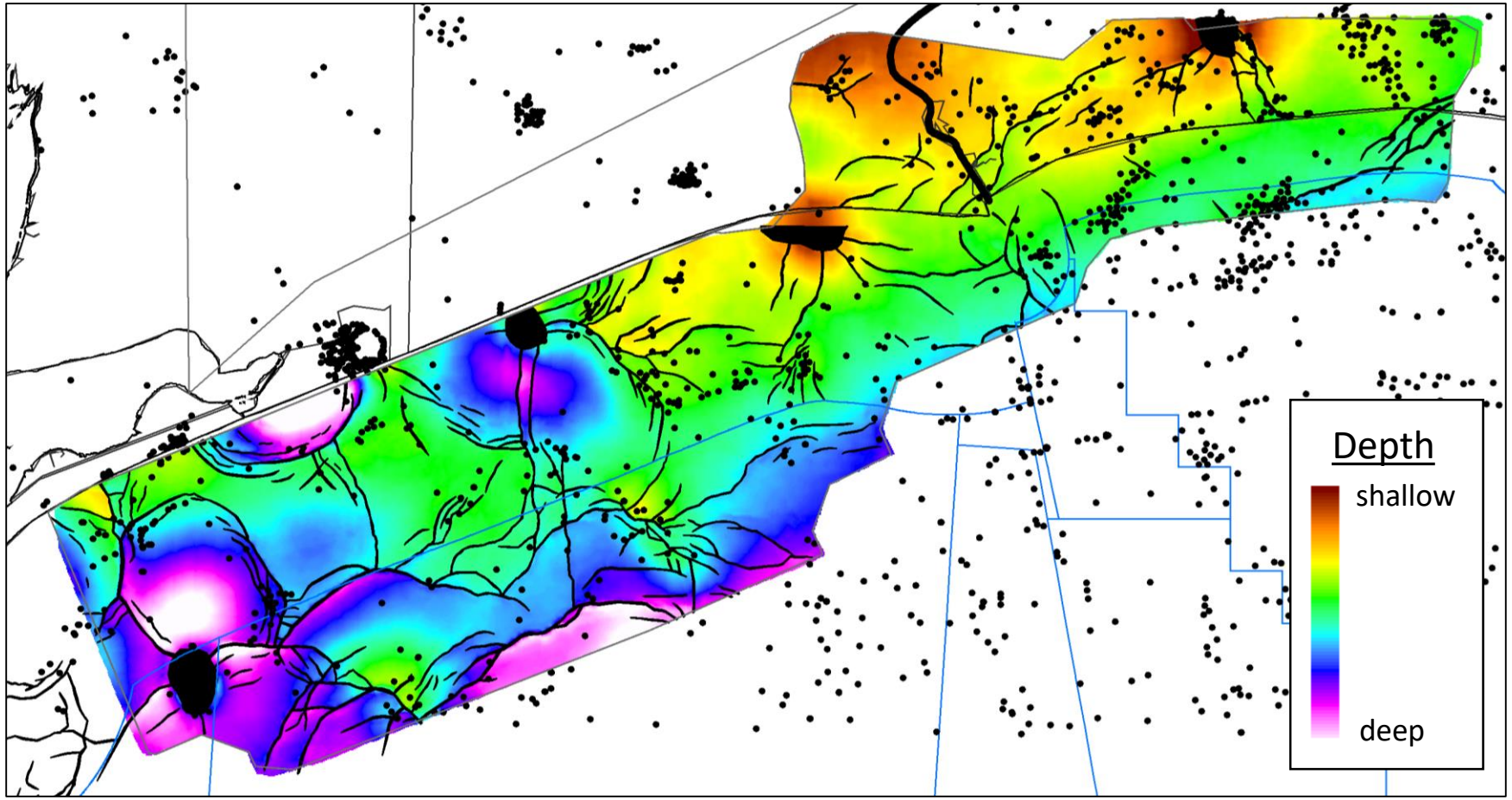


Seismic interpretation courtesy of Mike DeAngelo; Well data: IHS Enerdeq, 2022

GCCC GULF COAST CARBON CENTER

BUREAU OF ECONOMIC GEOLOGY

Wells Targeting Miocene Reservoirs



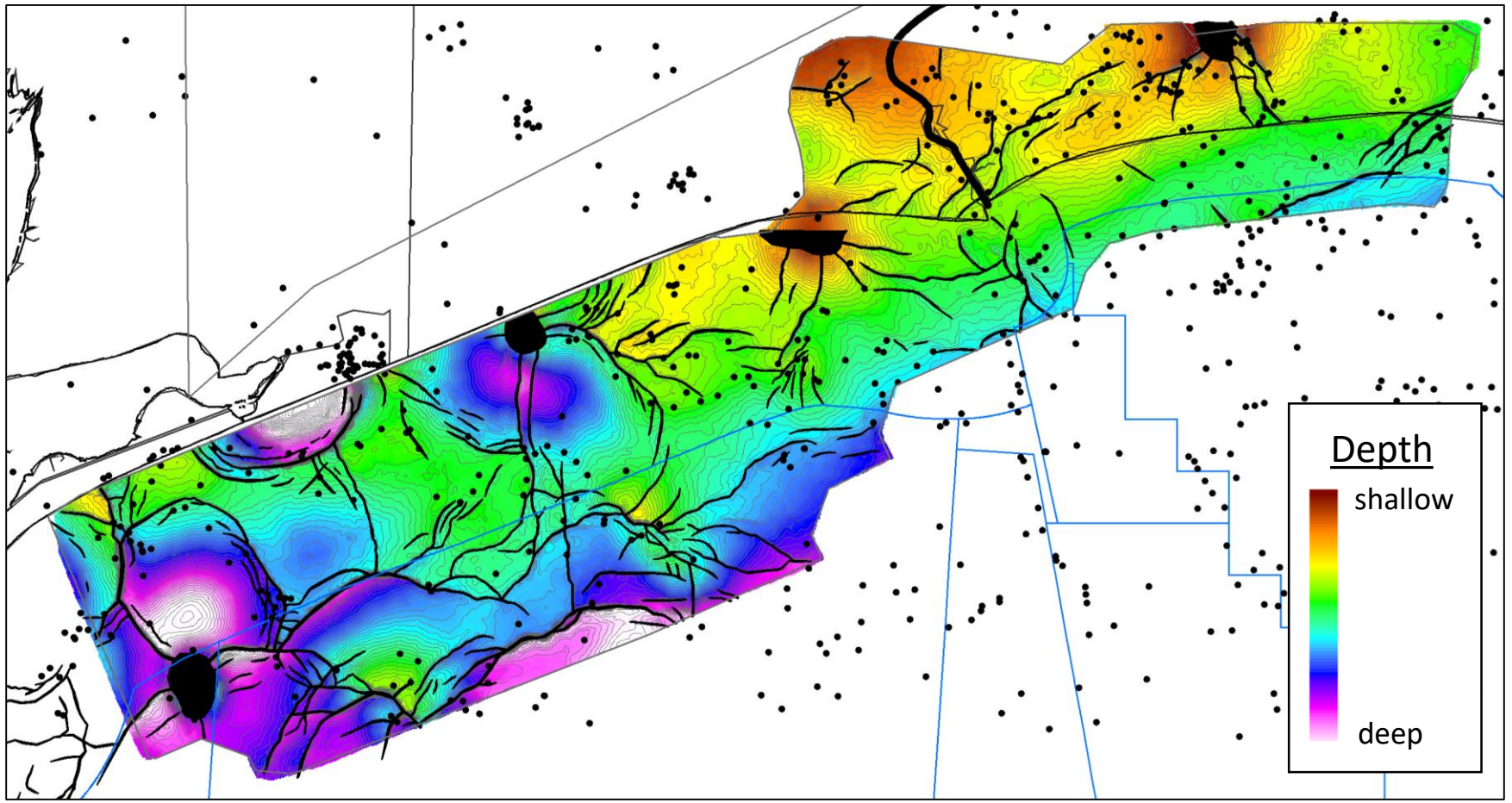
Seismic interpretation courtesy of Mike DeAngelo; Well data: IHS Enerdeq, 2022

GCCC GULF COAST CARBON CENTER

BUREAU OF ECONOMIC GEOLOGY

Miocene Dry Holes

Why did they fail?



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

GCCC GULF COAST CARBON CENTER

BUREAU OF ECONOMIC GEOLOGY

Exploration Success and Failure

Play Elements

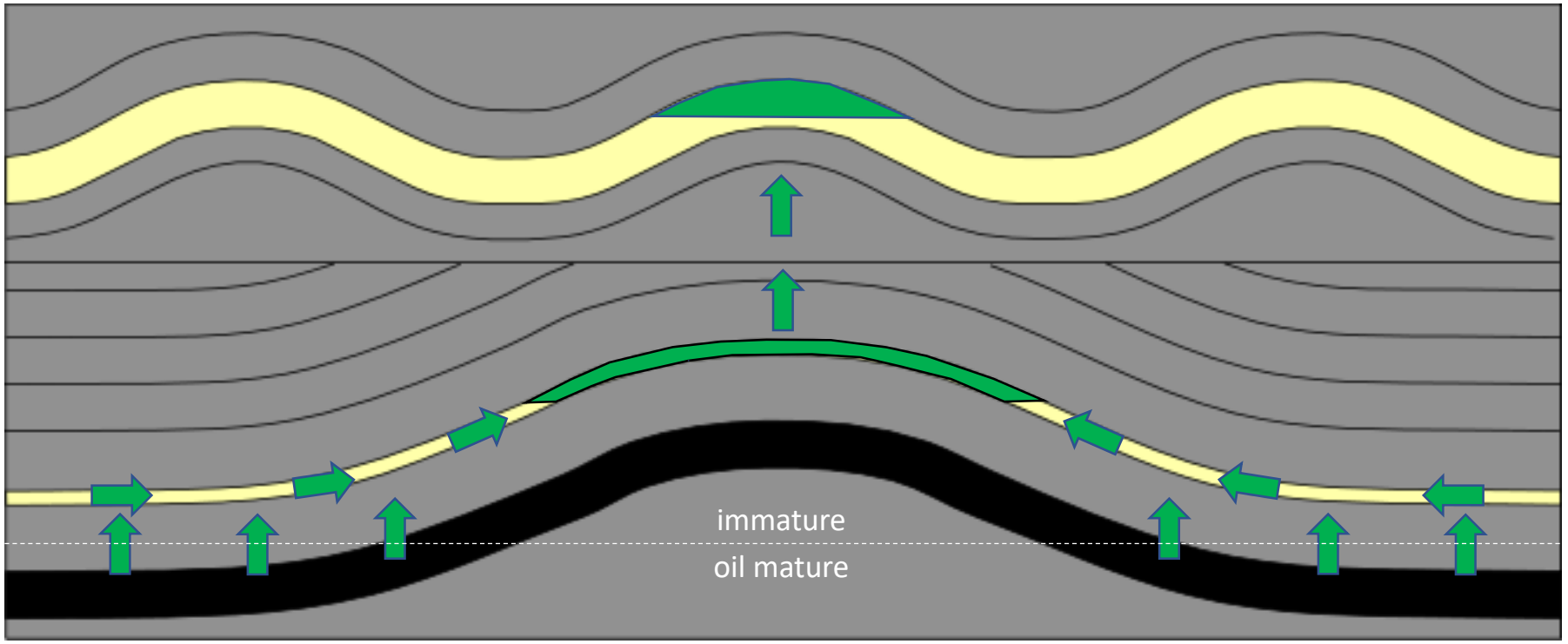
Seal

Trap

Reservoir

Charge access
- Thermal maturity
- Migration path

Source

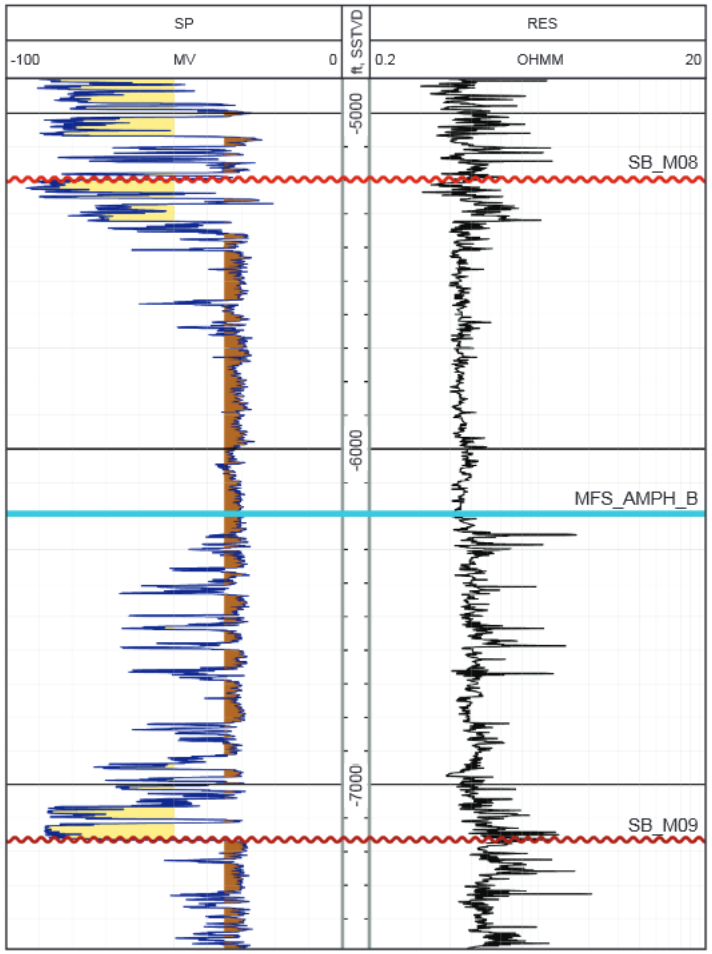


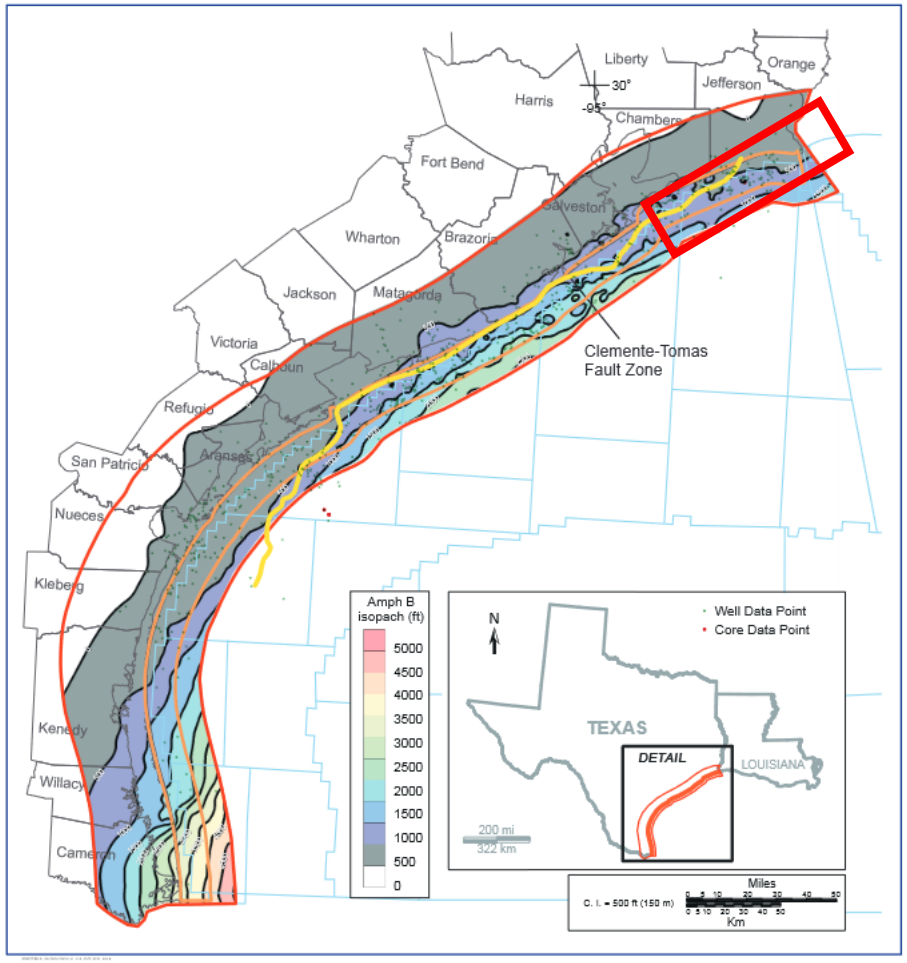
All elements need to work to create a producible hydrocarbon accumulation

GCCC GULF COAST CARBON CENTER

BUREAU OF ECONOMIC GEOLOGY

Amphistegina B Seal





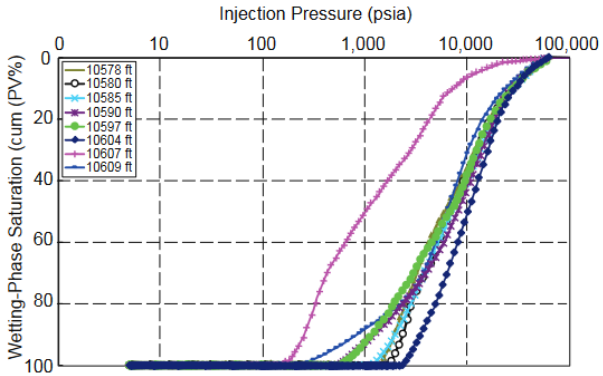


Figure 3.4a. Mercury-intrusion curves showing capillary entry pressure. Sample at 10,604 ft shows highest capillary entry pressure (2,146 psi), whereas sample at 10,607 ft shows lowest capillary entry pressure (137 psi).

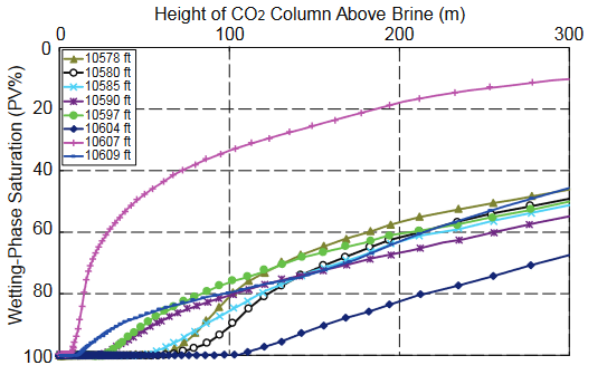


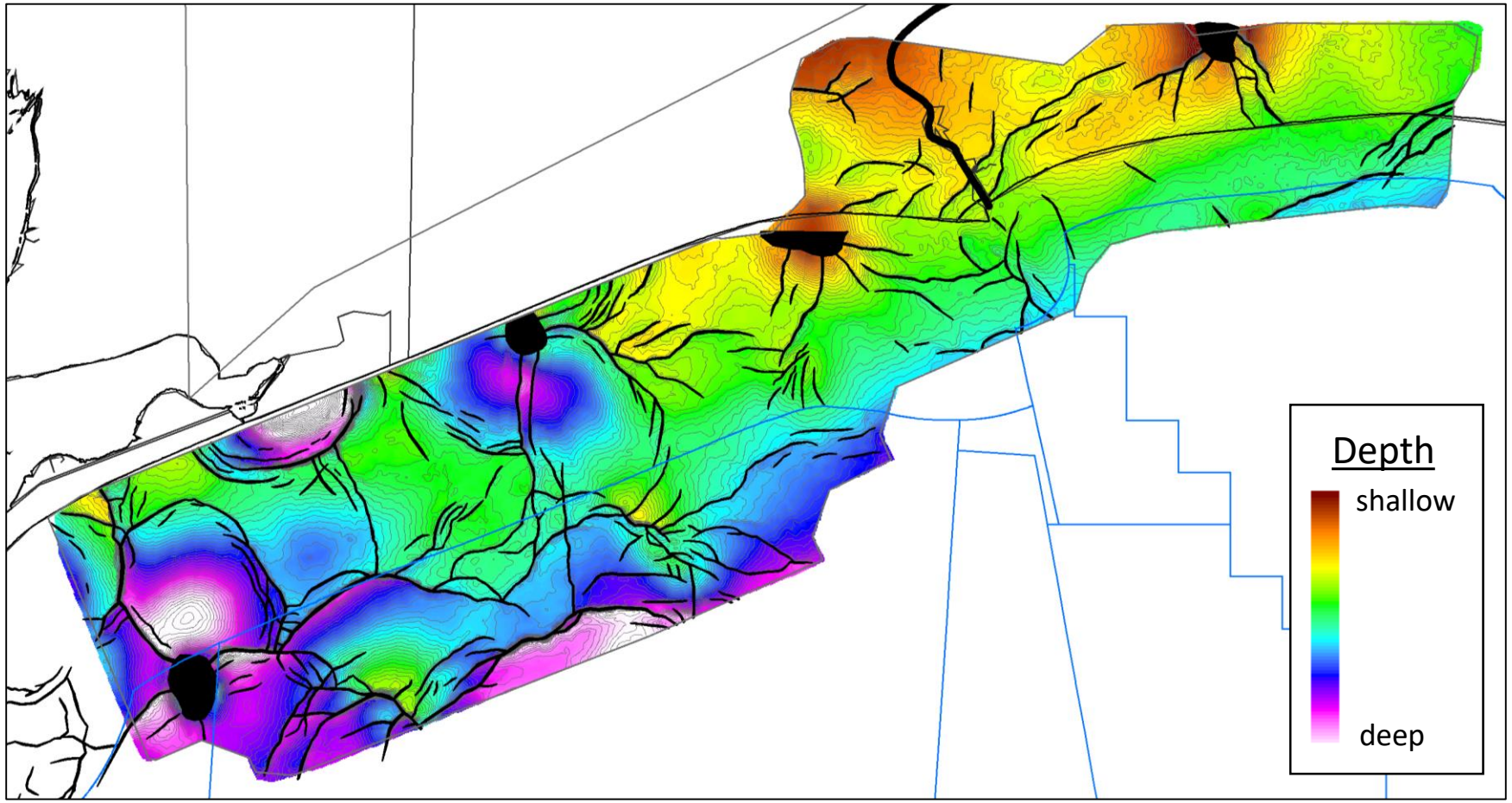
Figure 3.4b. Carbon dioxide (CO_2) column height calculated from mercury intrusion capillary entry pressure at 70°C and 20 MPa. Samples from well OCS-G-4708 #1 (well 2, fig. 3.1).

Lu et al, 2018

GCCC GULF COAST CARBON CENTER

BUREAU OF ECONOMIC GEOLOGY

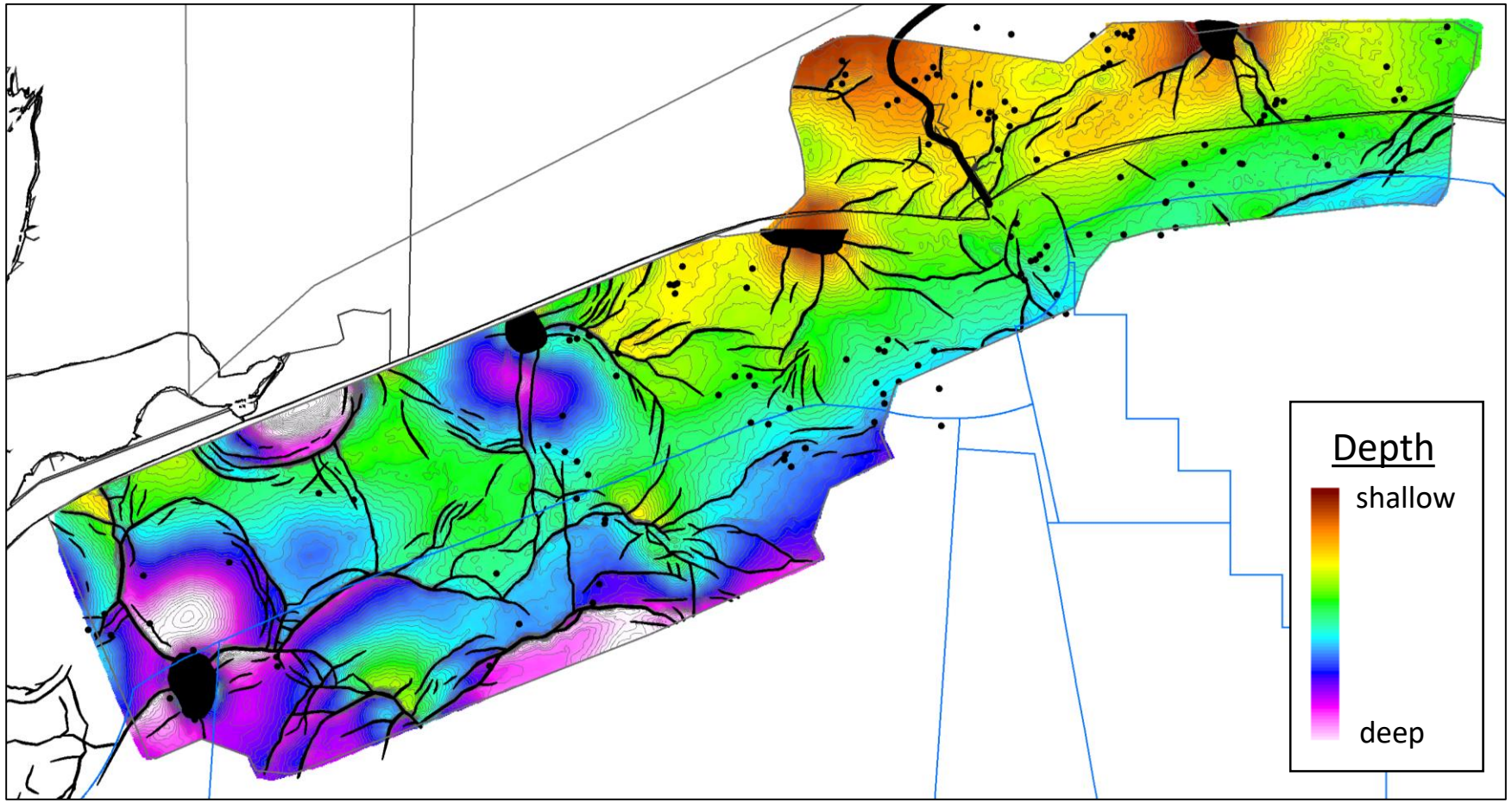
Trap



Miocene Seal with contours

Seismic interpretation courtesy of Mike DeAngelo

No Structural Trap

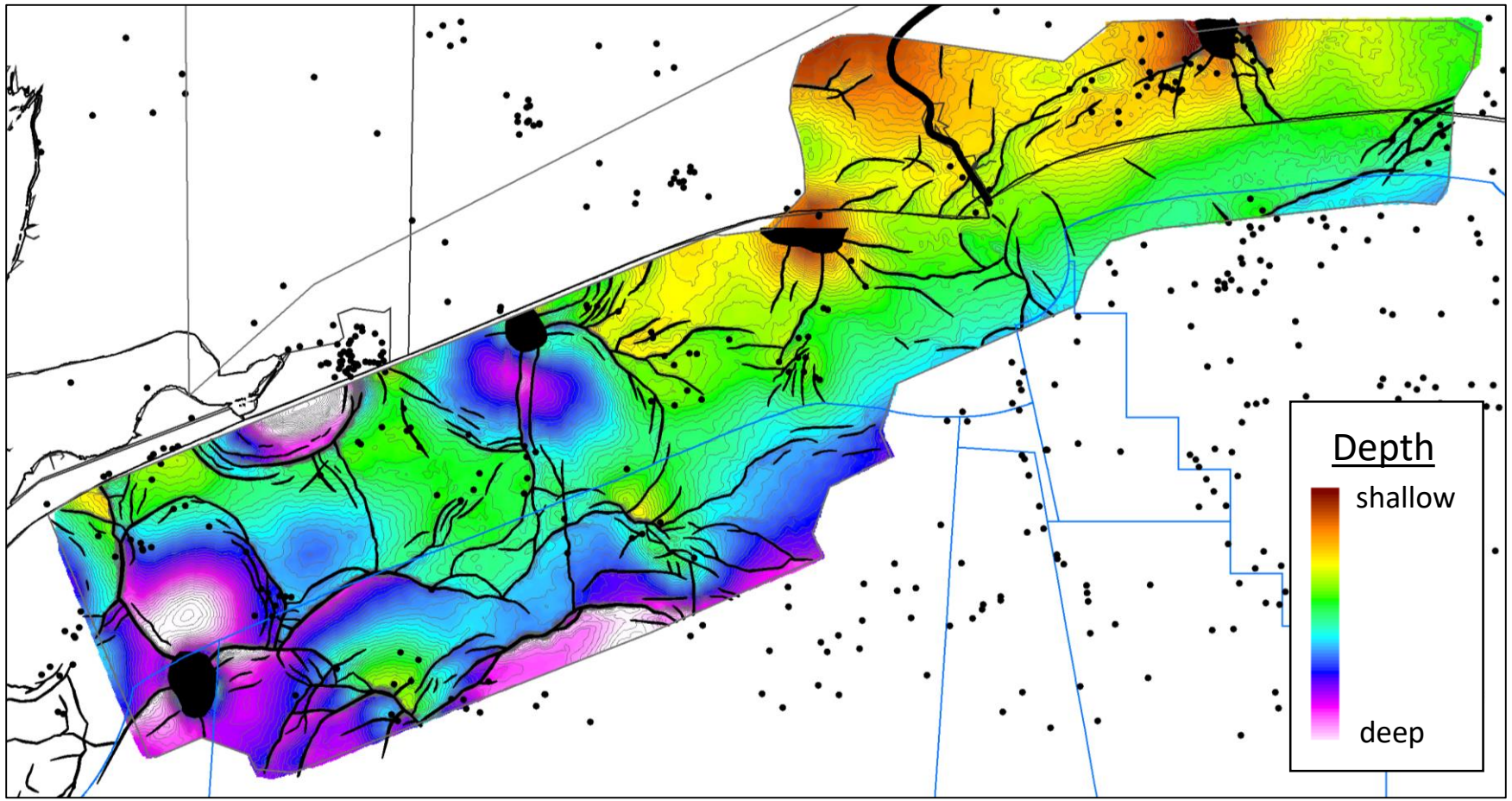


Seismic interpretation courtesy of Mike DeAngelo; Well data: IHS Enerdeq, 2022

GCCC GULF COAST CARBON CENTER

BUREAU OF ECONOMIC GEOLOGY

Dry Holes with Valid Trap

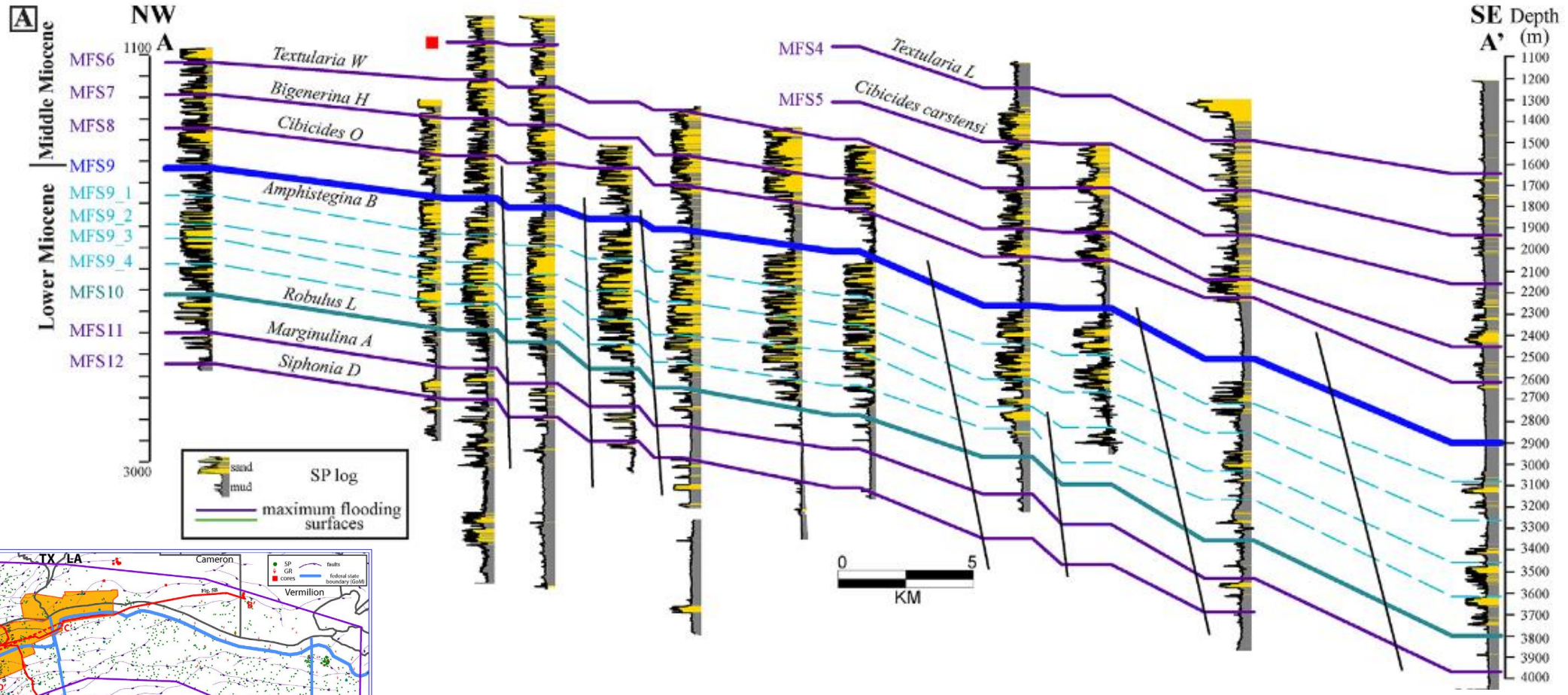


Seismic interpretation courtesy of Mike DeAngelo; Well data: IHS Enerdeq, 2022

GCCC GULF COAST CARBON CENTER

BUREAU OF ECONOMIC GEOLOGY

Coastal Texas Miocene Reservoirs



Possible that wells failed to find specific target sands
unlikely that they failed to find any producible sands

Olariu et al, 2019

GCCC GULF COAST CARBON CENTER

BUREAU OF ECONOMIC GEOLOGY

Charge Focus

Play Elements

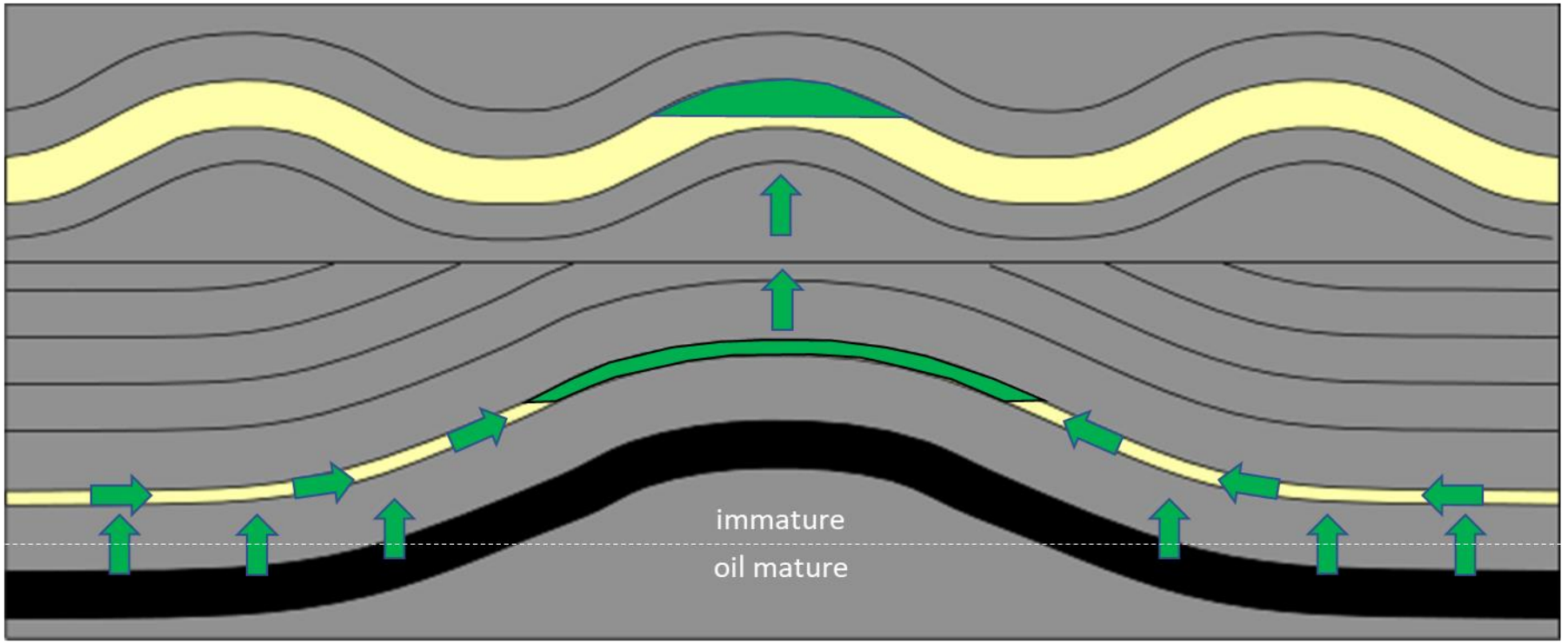
Seal

Trap

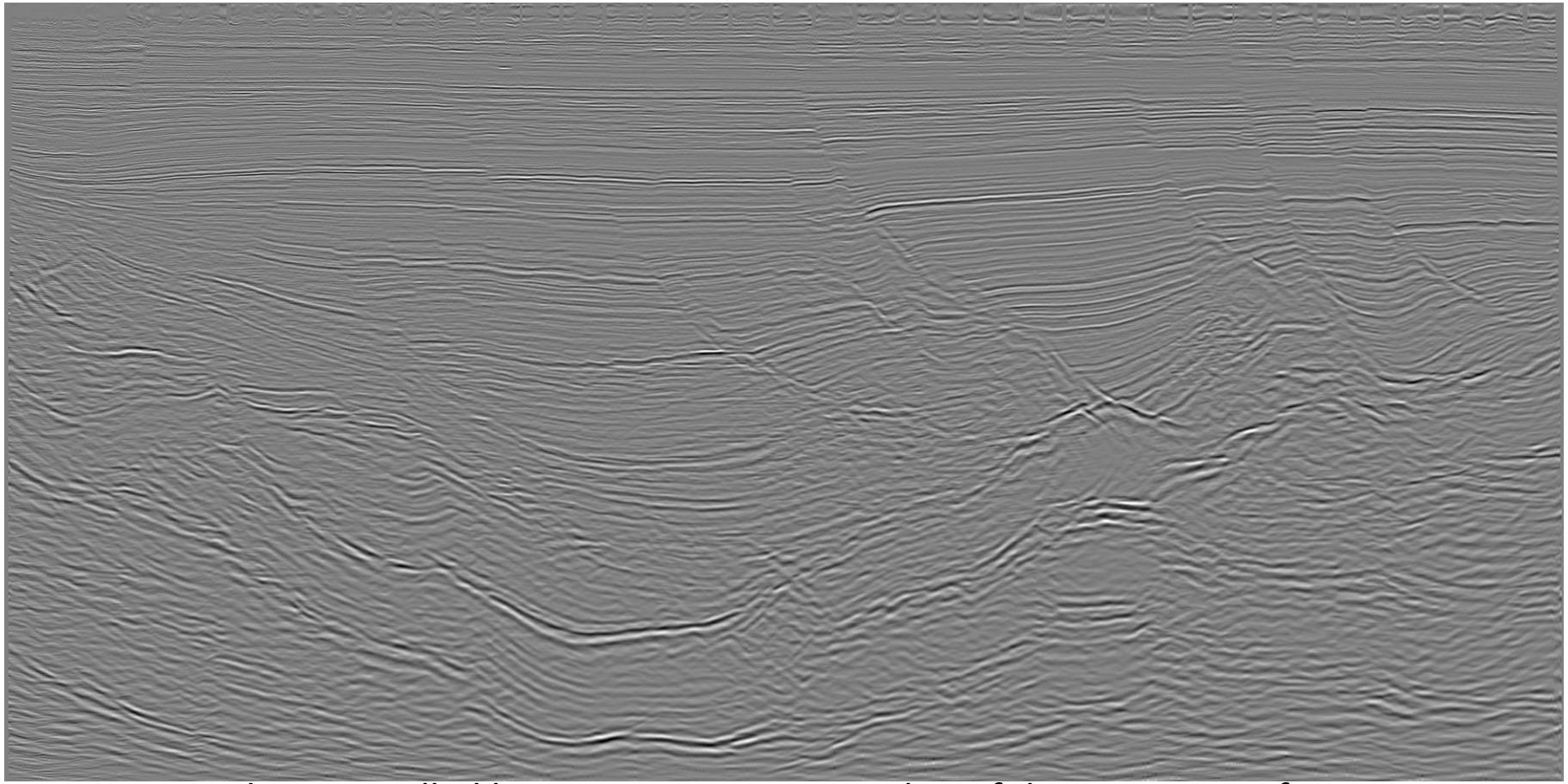
Reservoir

Charge access
- Thermal maturity
- Migration path

Source

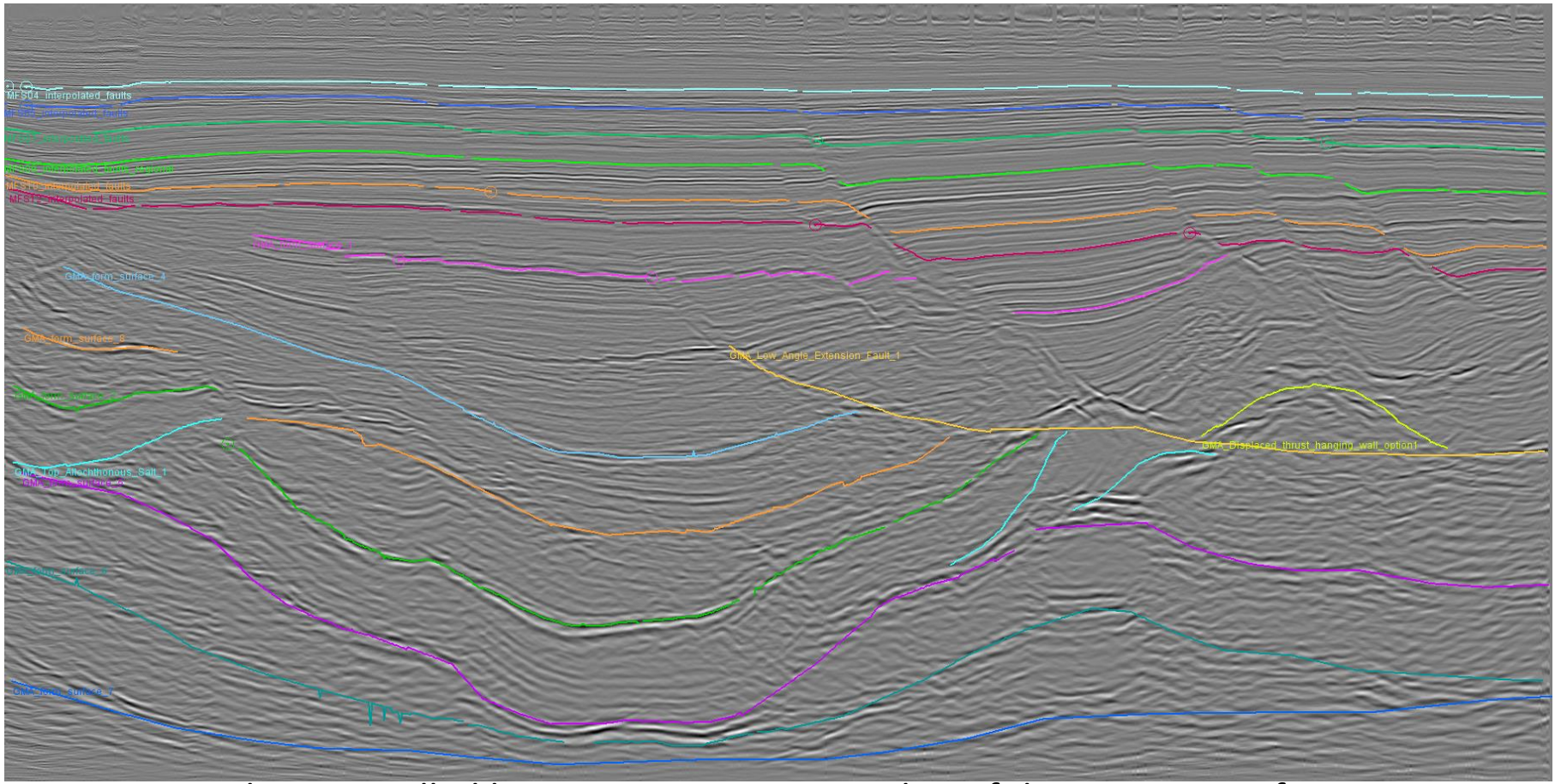


Significant Areas of Disharmonic Structure



Data owned or controlled by SEI. Interpretation is that of the University of Texas at Austin

Multiple Phases of Salt Withdrawal



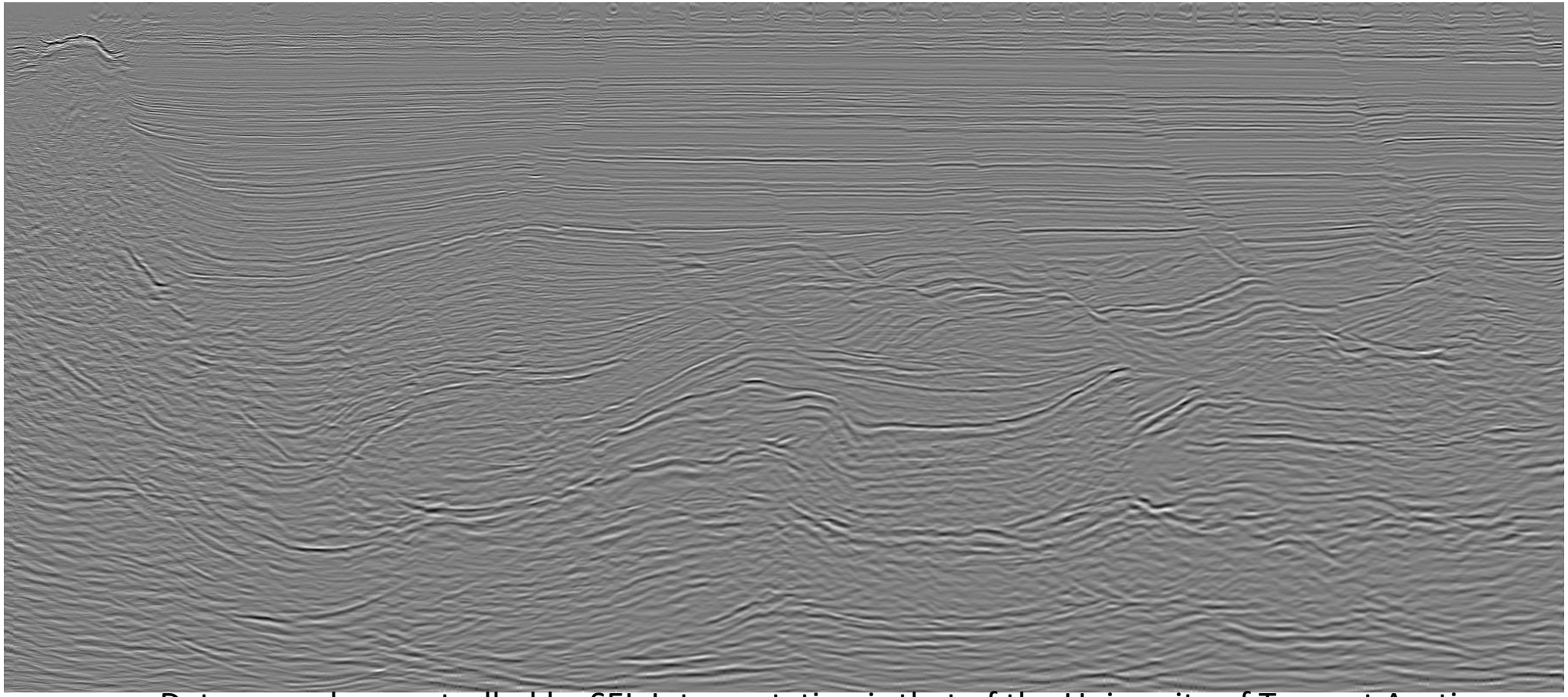
Data owned or controlled by SEI. Interpretation is that of the University of Texas at Austin

GCCC GULF COAST CARBON CENTER

BUREAU OF ECONOMIC GEOLOGY

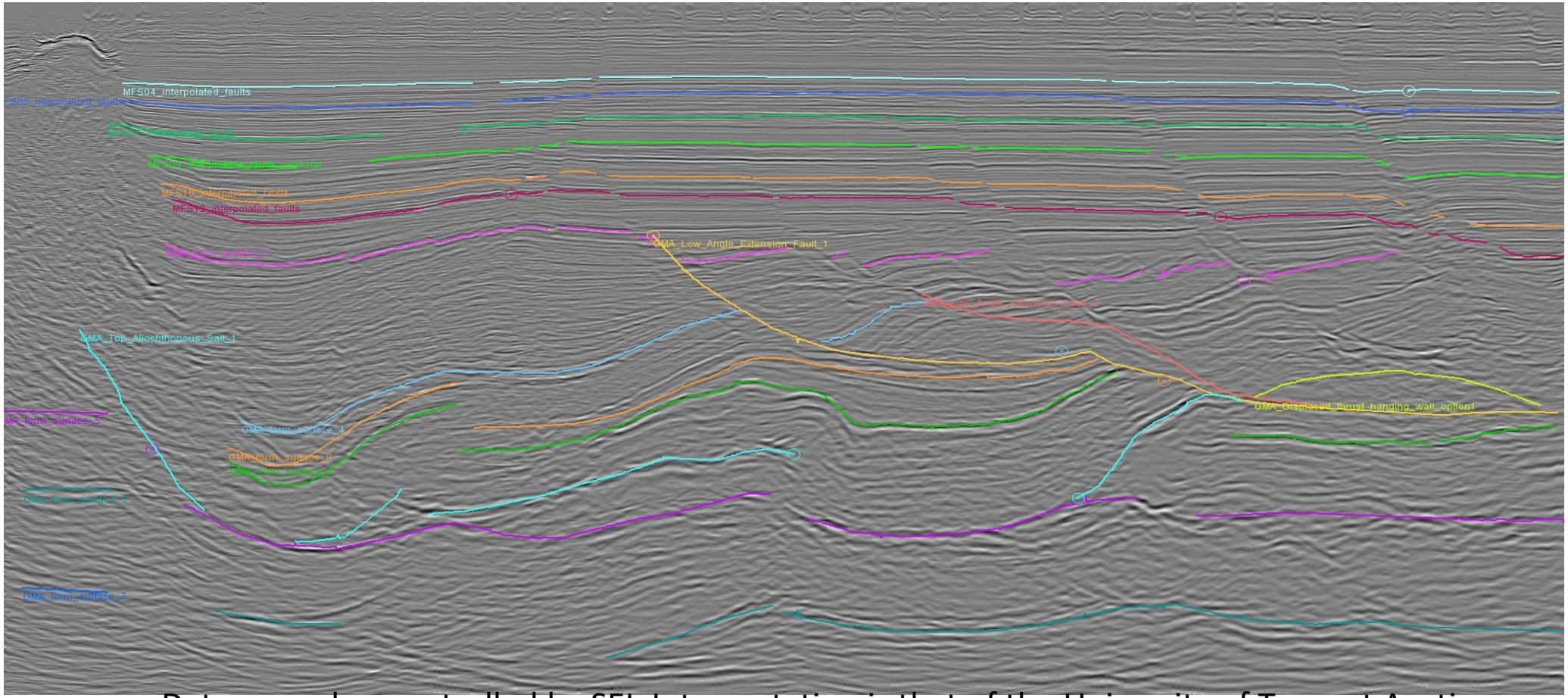
SEI®

More Complexity



Data owned or controlled by SEI. Interpretation is that of the University of Texas at Austin

Early thrusts cut by later extensional faults



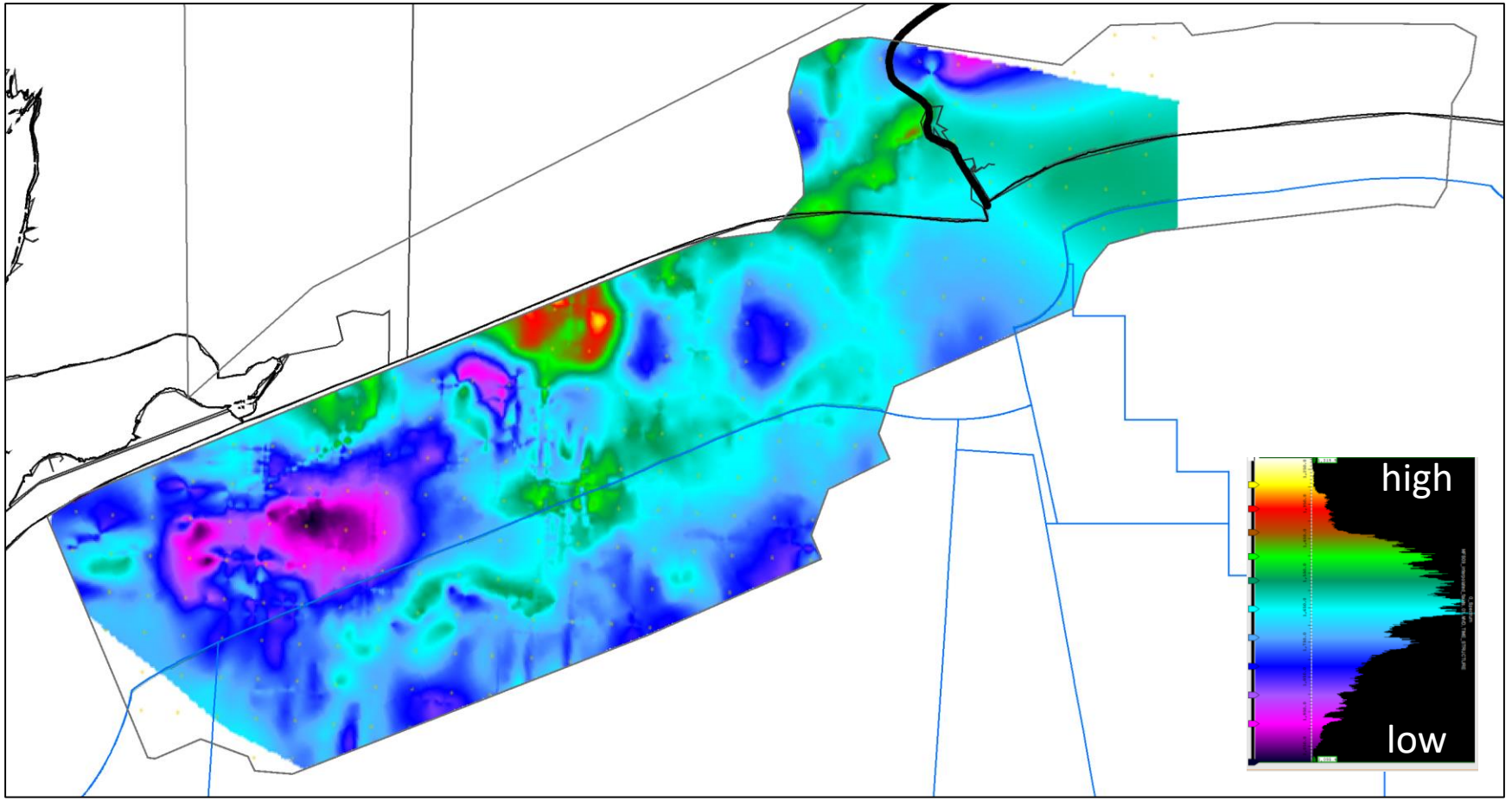
Data owned or controlled by SEI. Interpretation is that of the University of Texas at Austin

GCCC GULF COAST CARBON CENTER

BUREAU OF ECONOMIC GEOLOGY

SEI®

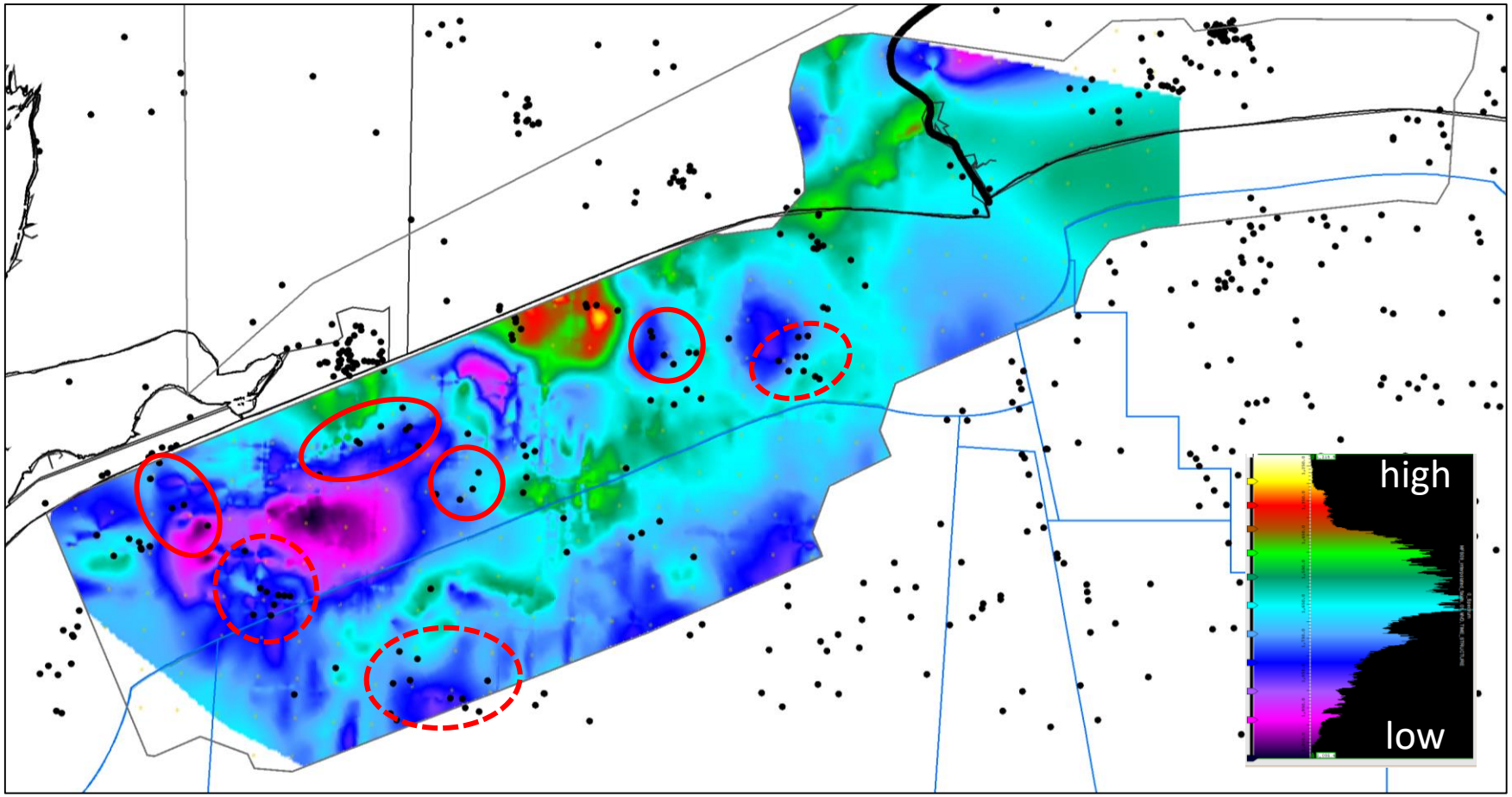
Oligocene Structure



GCCC GULF COAST CARBON CENTER

BUREAU OF ECONOMIC GEOLOGY

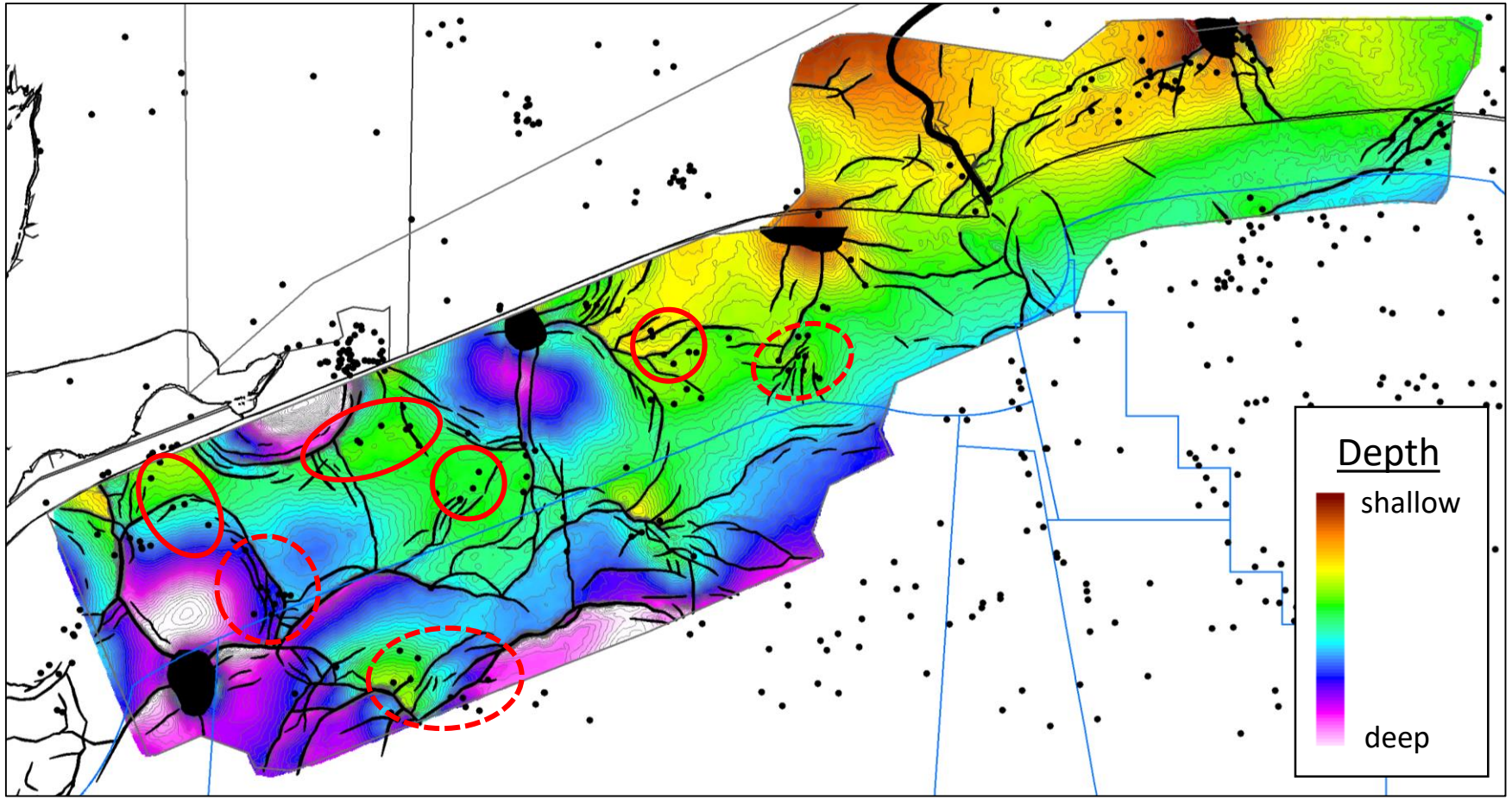
Oligocene Focus with Miocene dry holes



Circles show defocused charge

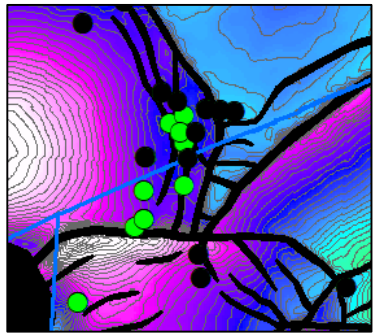
Well data: IHS Enerdeq, 2022

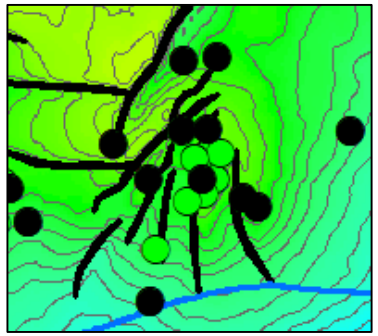
Dry Holes with Valid Trap but No Charge Focus



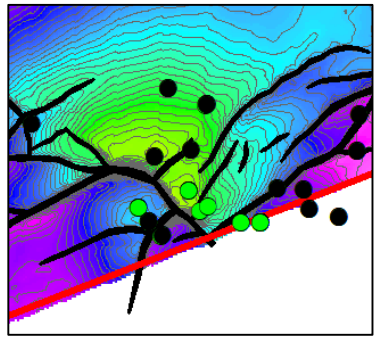
Seismic interpretation courtesy of Mike DeAngelo; Well data: IHS Enerdeq, 2022

Mixed Production and Dry Holes





- Production intermixed with dry holes
- Clearly charge and trap are working
- Patchy seal would result in all wells failing
- Interpretation: Channelized reservoirs—some wells miss the charged intervals



- Down-dip wells are dry
- Crestal production
- Interpretation: Limited seal capacity, most likely in the bounding fault

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 update allows us to discount the dry holes in our assessment of top seal for CCS

Next Steps

- Build a local basin model to more accurately model charge access
- Refine subdivision of dry holes by target interval where possible
- Add column height data where possible
- Look for evidence of leakage to calibrate top seal capacity
- Look more closely at fault seal