Geological and Geomechanical Characteristics of the Potential CO_2 Storage Reservoirs, Eastern Gulf of Mexico

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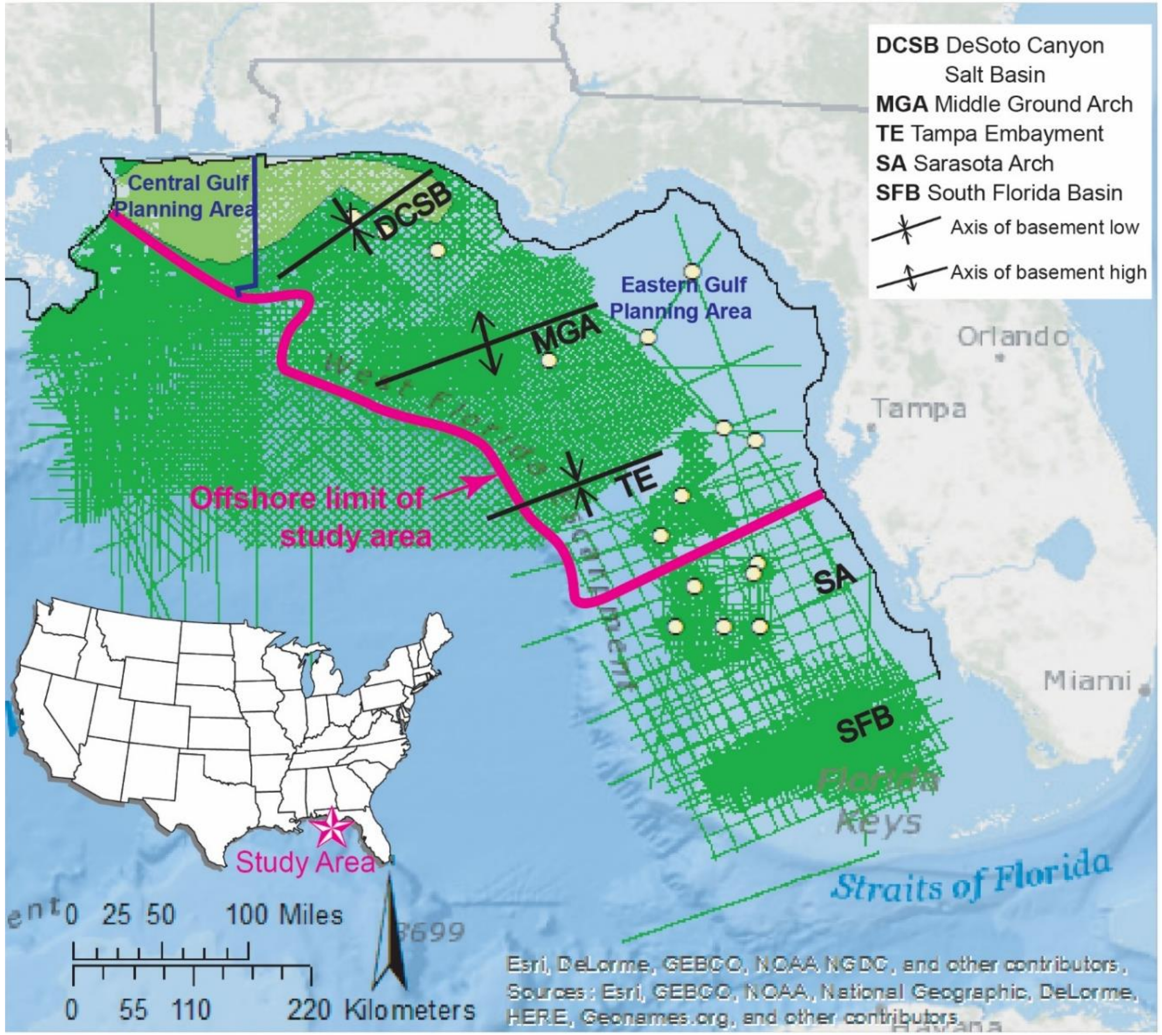
Introduction

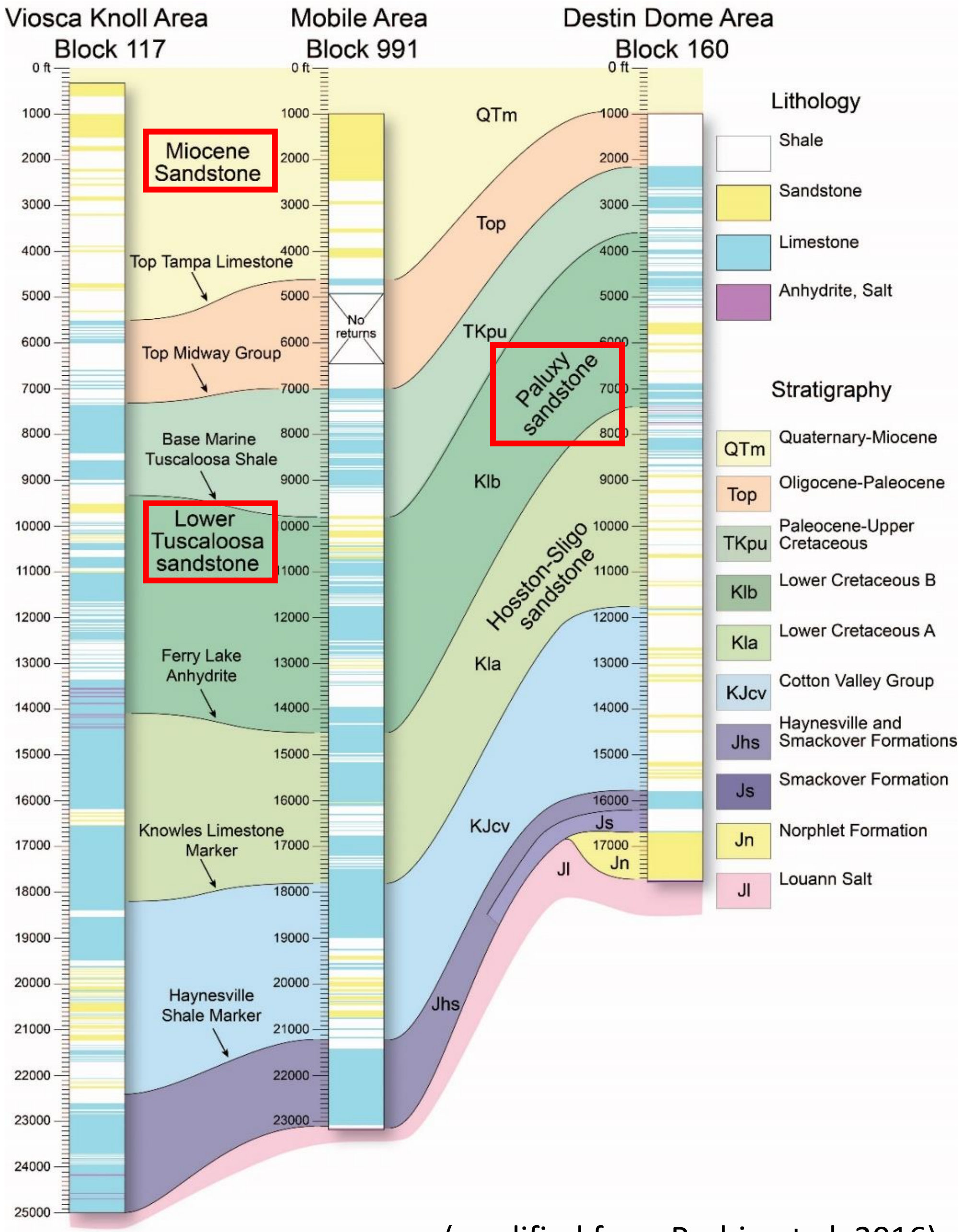
- Subsurface geologic storage of CO_2 can play a major role in offsetting greenhouse gas emissions.
- Offshore storage offers an attractive alternative to onshore storage in the east Gulf of Mexico Area.
  - Potential gigatonne-class storage capacity (Hills and Pashin, 2010, Chandra, 2018).
  - One owner (Federal Government) for leasing and pipeline siting.
  - Successful onshore CCS projects (Cranfield, MS; Plant Daniel, MS; Plant Barry, AL).
  - Proven offshore storage technology (Sleipner and Snøhvit, Norway).
- Ensuring safe, permanent storage is essential for CO_2 sequestration.

Objective: Perform a comprehensive structural and geomechanical study of potential storage units to identify the favorable storage sites that have minimal risk of injected CO_2 migrating out of the storage complex.

Geological Setting



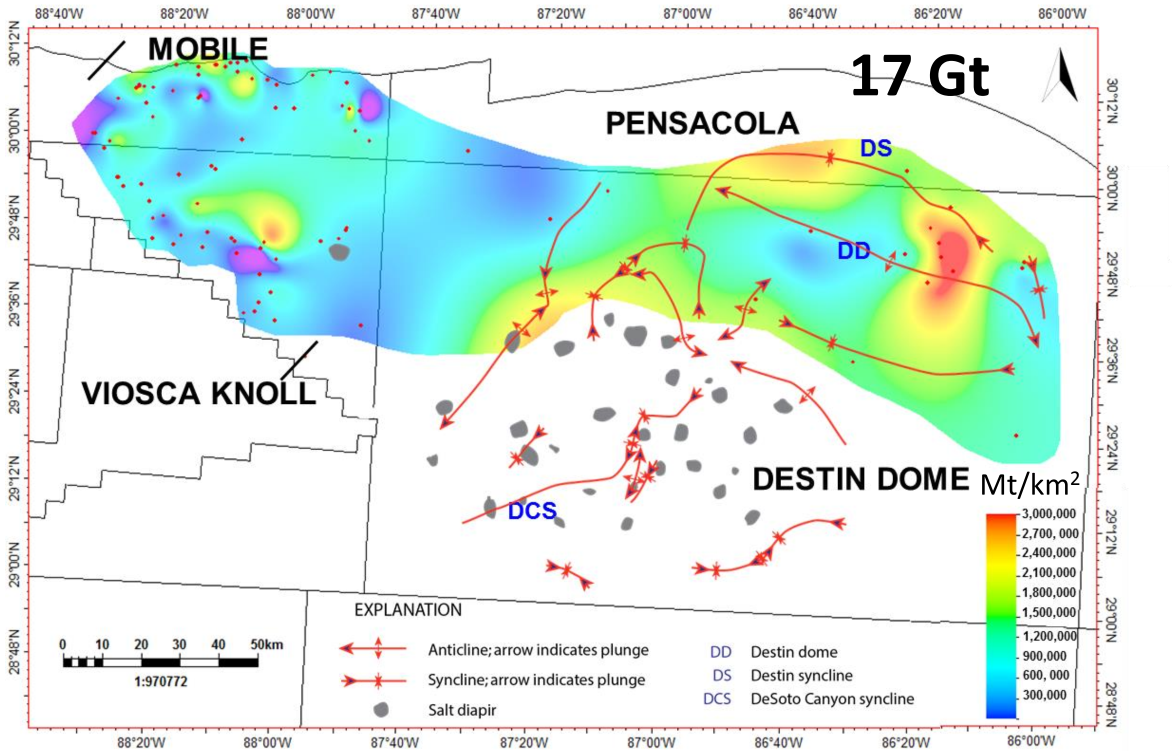
Green lines show reflection seismic control, white dots and shaded area show well control. Data source: Bureau of Ocean Energy Management (BOEM)



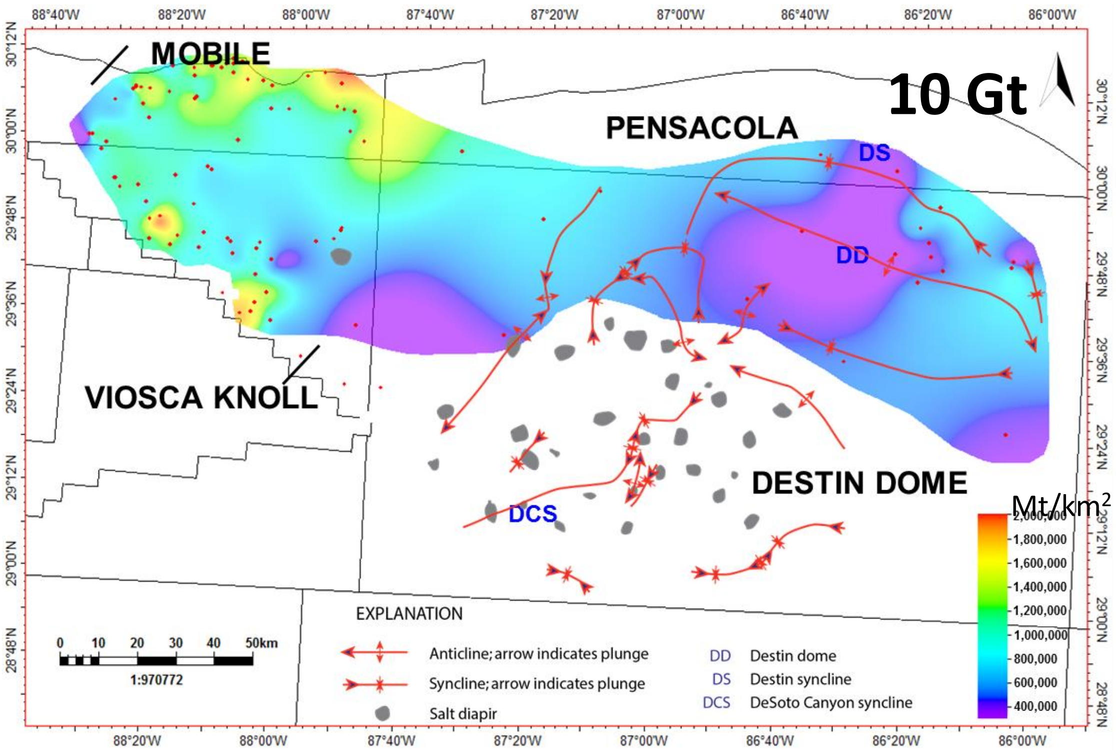
(modified from Pashin et al, 2016)

P_{50} Storage Resource—DeSoto Canyon Salt Basin

Paluxy Formation



Tuscaloosa Group



Efficiency factors based on displacement terms for sandstone

Categories	Paluxy	Washita-Fredericksburg	Lower Tuscaloosa
Reservoir Capacity at 100% CO_2 Saturation (Gt)	122.4	7.5	69.7
Efficiency Factor (P_{10}) %	7.40	7.40	7.40
Efficiency Factor (P_{50}) %	14.00	14.00	14.00
Efficiency Factor (P_{90}) %	24.00	24.00	24.00
Reservoir CO_2 Storage Resource (P_{10}) (Gt)	9.06	0.56	5.16
Reservoir CO_2 Storage Resource (P_{50}) (Gt)	17.13	1.06	9.76
Reservoir CO_2 Storage Resource (P_{90}) (Gt)	29.37	1.81	16.73

Qualified sandstone:
Thickness > 6 m
Porosity > 15%

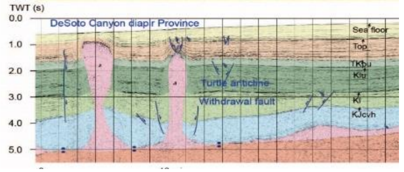
Individual offshore block can help offsetting CO_2 emissions from up to 13 power plants annually

(modified from Chandra, 2018)

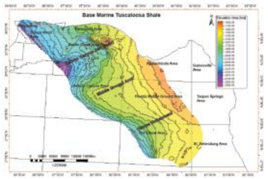
Methods

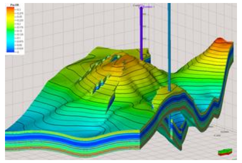
Structural Analysis

Seismic interpretation



Structural mapping and modeling



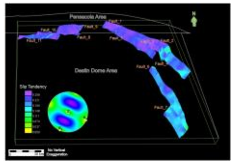


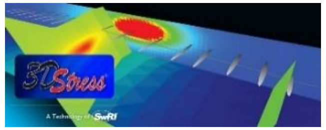
Fault Analysis

Fault reactivation tendency

Slip tendency

Dilation tendency

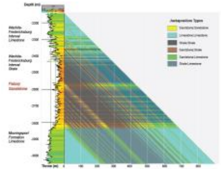


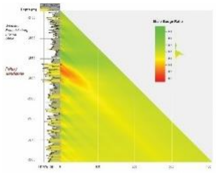


Fault seal analysis

Juxtaposition

Shale gauge ratio

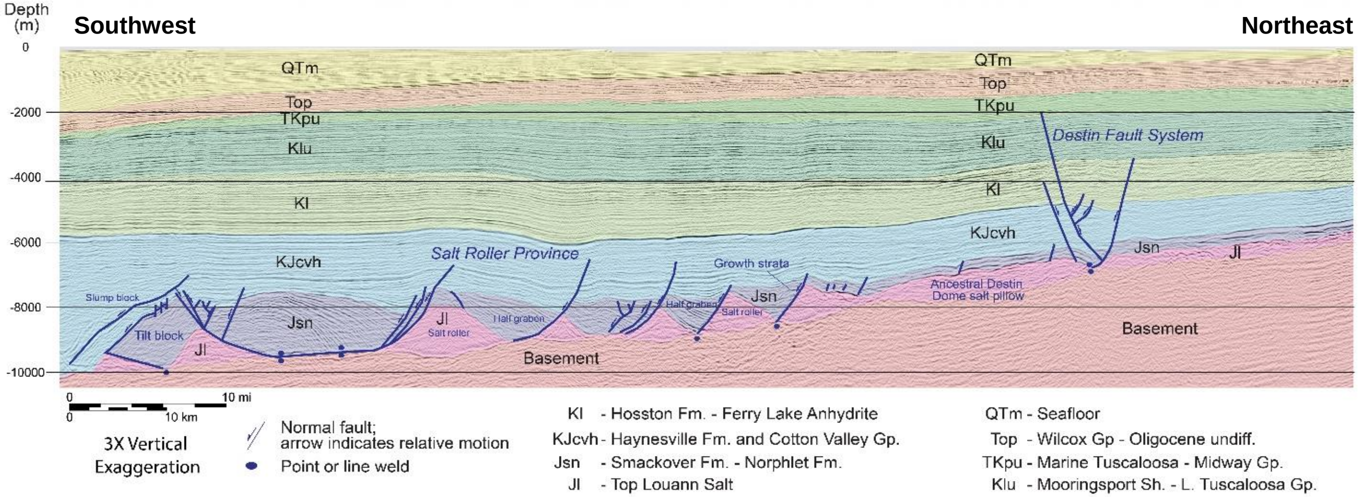




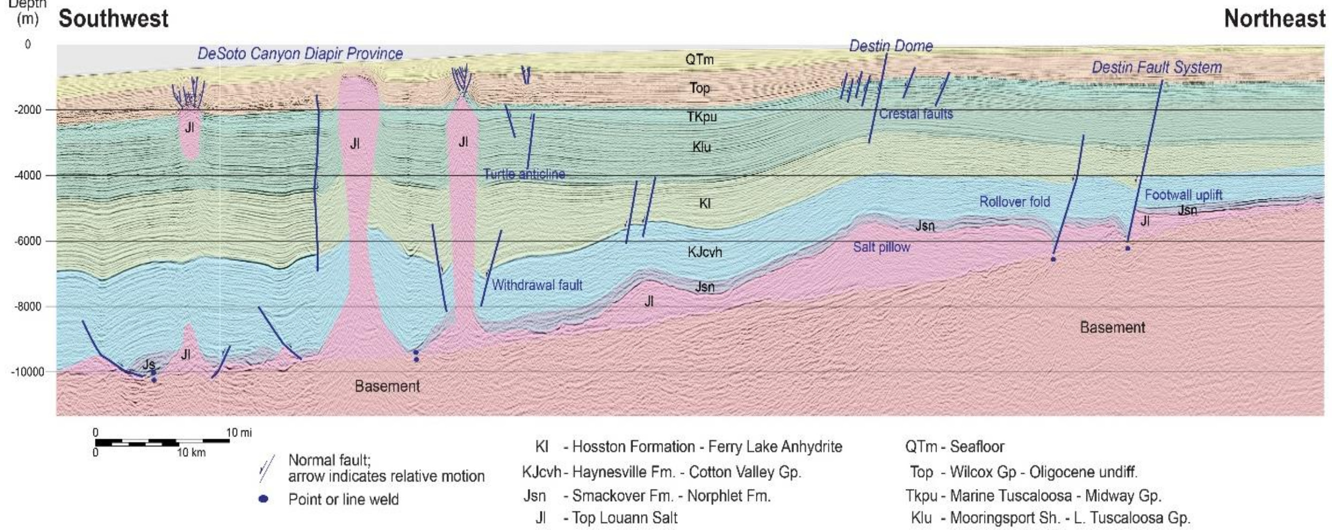
Identify the favorable storage sites that have minimal risk of injected CO_2 migrating out of zone

Result: Structural Framework

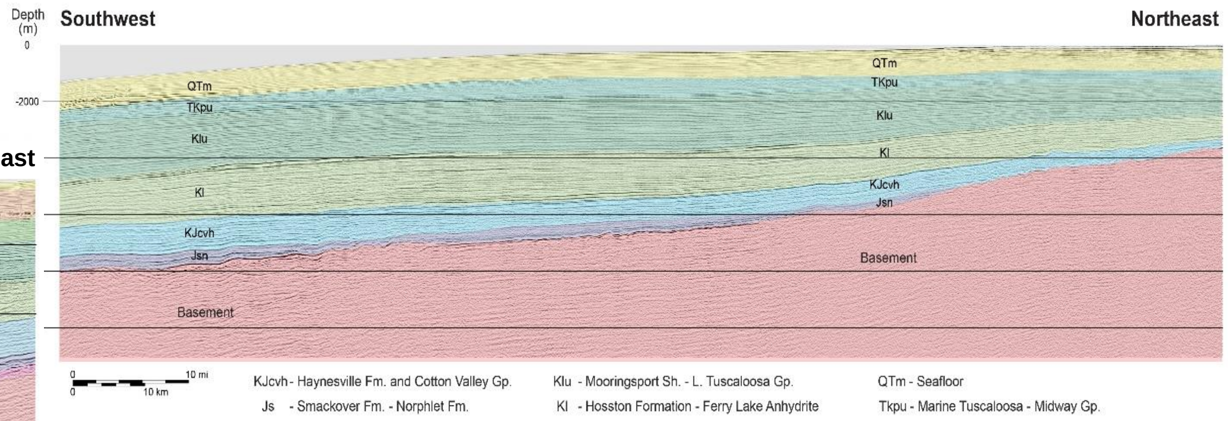
Line d8519

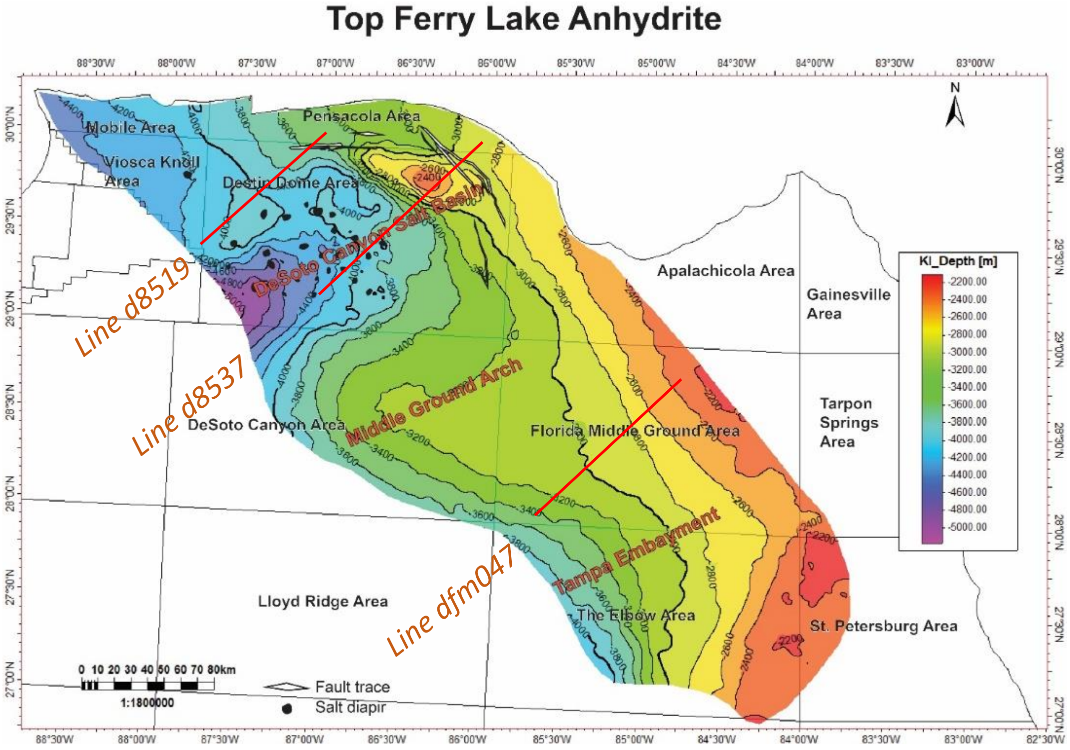


Line d8537

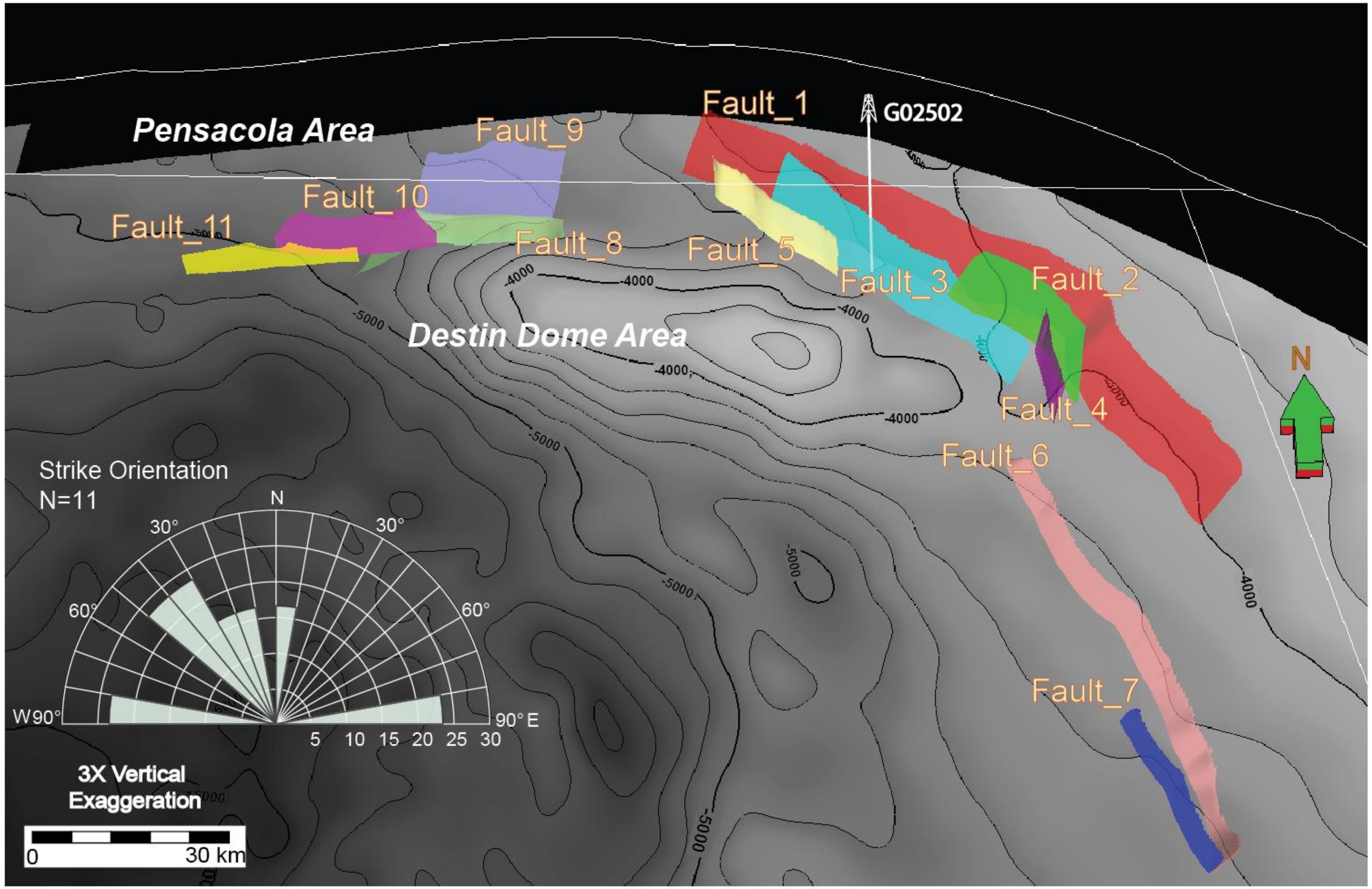


Line dmf047

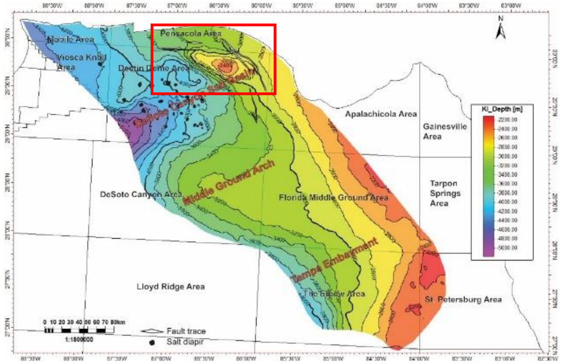




Destin Fault System



3D visualization of the major faults in the Destin Fault System. Rose diagram showing the fault orientation. Contoured surface is the top of the Knowles Limestone (top KJcvh).

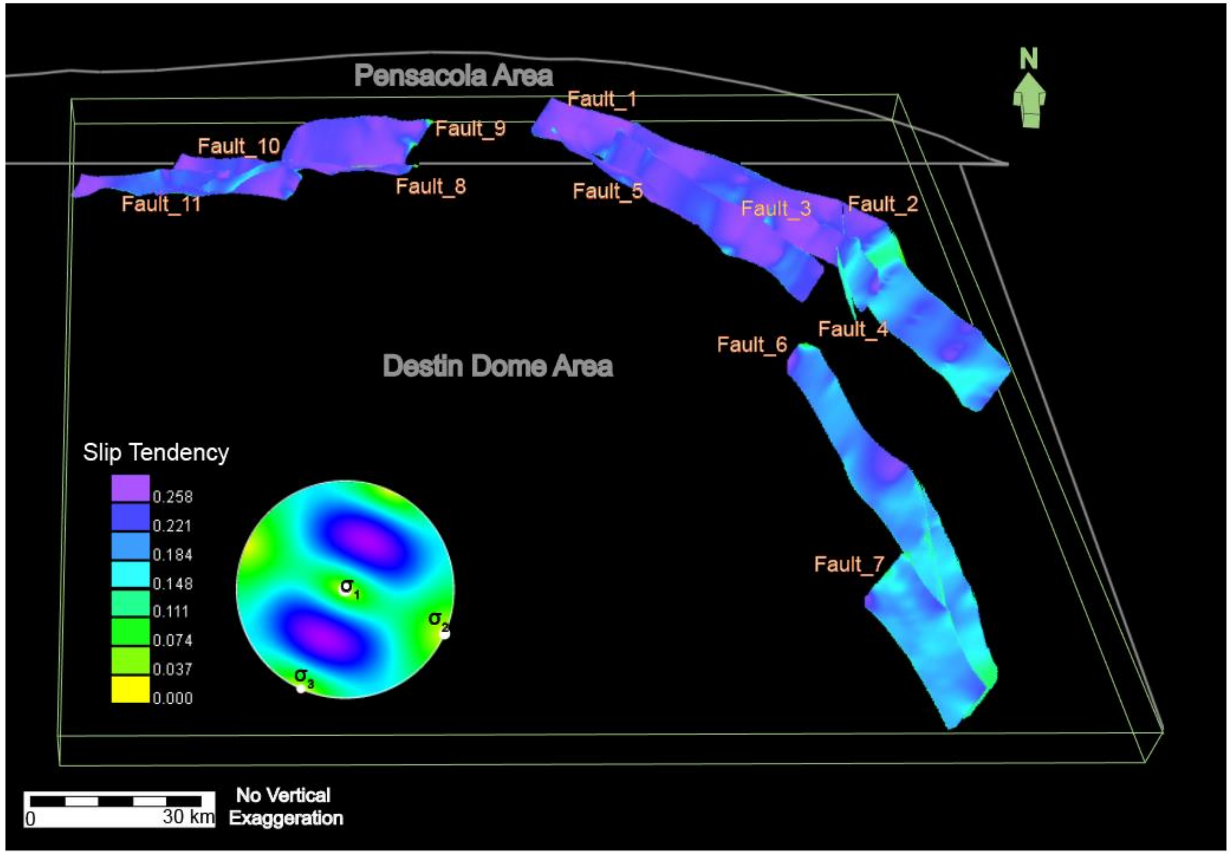


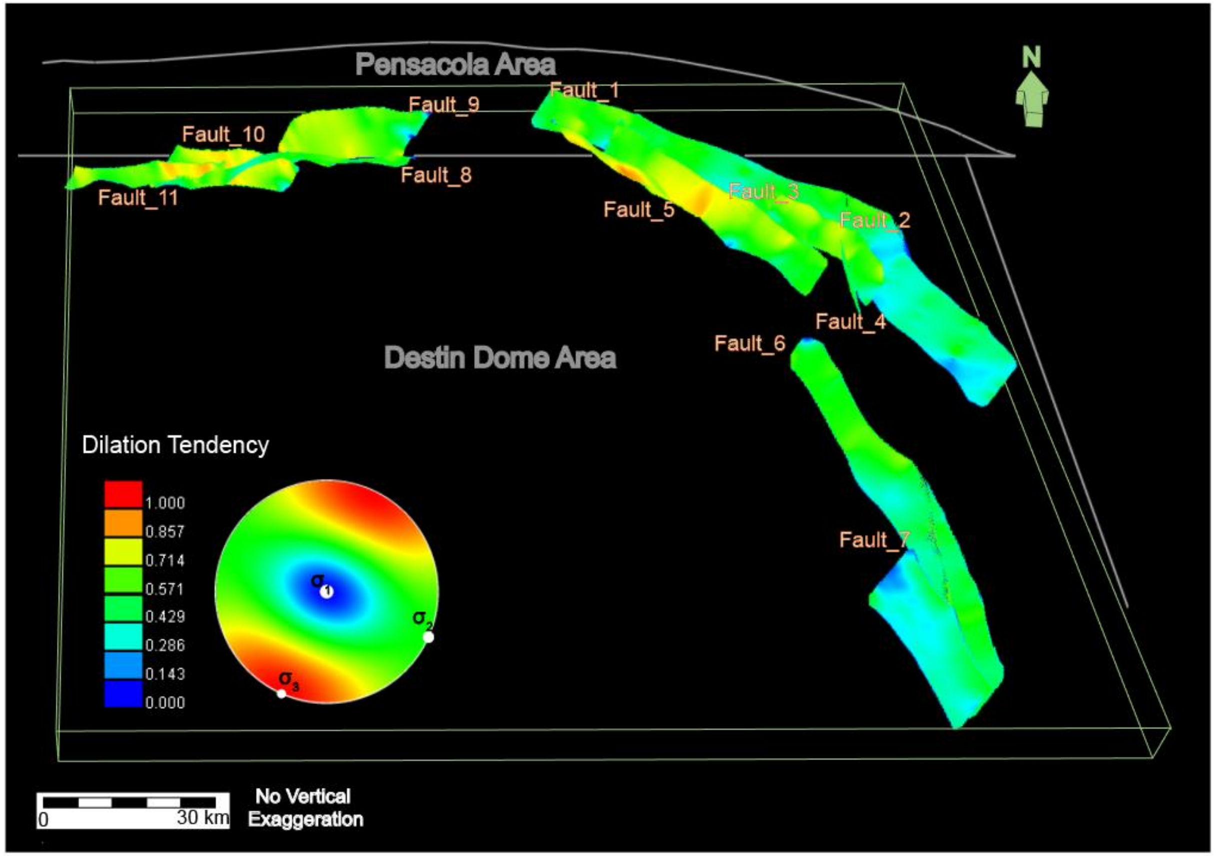
Fault Group	Fault Name	Strike (°)	Dip (°)	Dip Direction
Group_1	Fault_1	N47°W	40	SW
	Fault_2	N38°W	52	SW
	Fault_3	N40°W	54	SW
	Fault_4	N4°E	62	E
	Fault_5	N42°W	59	NE
Group_2	Fault_6	N13°W	54	SW
	Fault_7	N30°W	40	SW
Group_3	Fault_8	N82°E	46	S
	Fault_9	N87°W	52	N
	Fault_10	N88°W	55	S
	Fault_11	N88°E	58	S

Slip and Dilation Tendency

Principal Stresses Field

- SH_{max} orientation: NW-SE, Average 114°.
- Sv , Pp have a power-law relationship to depth.
- Geometric mean of Sh_{min} corresponds to an effective stress quotient.



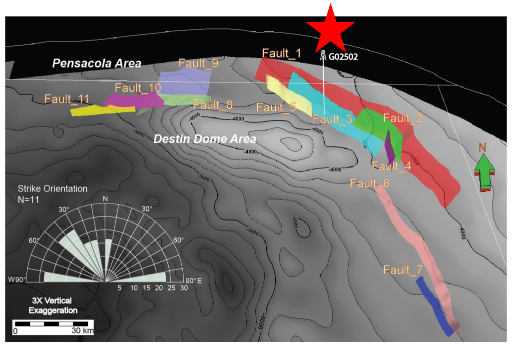


$T_s = \tau / \sigma_n$ **Slip Tendency**

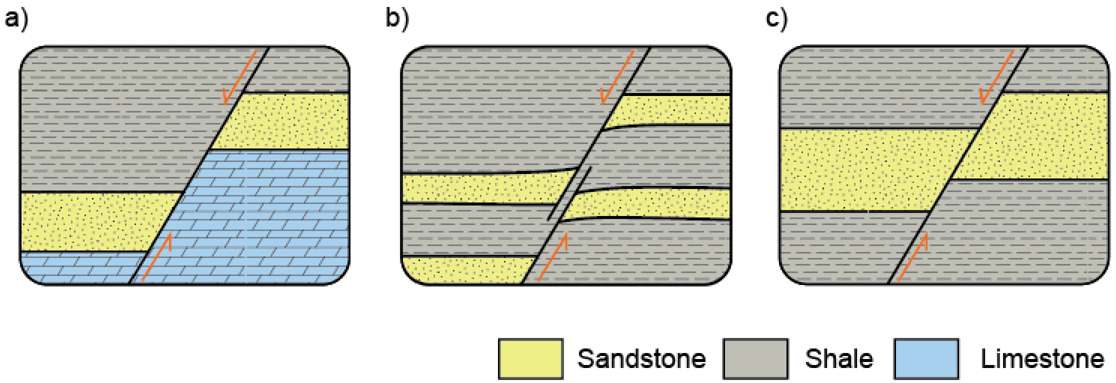
$T_d = (\sigma_1 - \sigma_n) / (\sigma_1 - \sigma_3)$ **Dilation Tendency**

(Stress information from Meng et al, in revision)

Fault Seal Analyses



Juxtaposition Seal

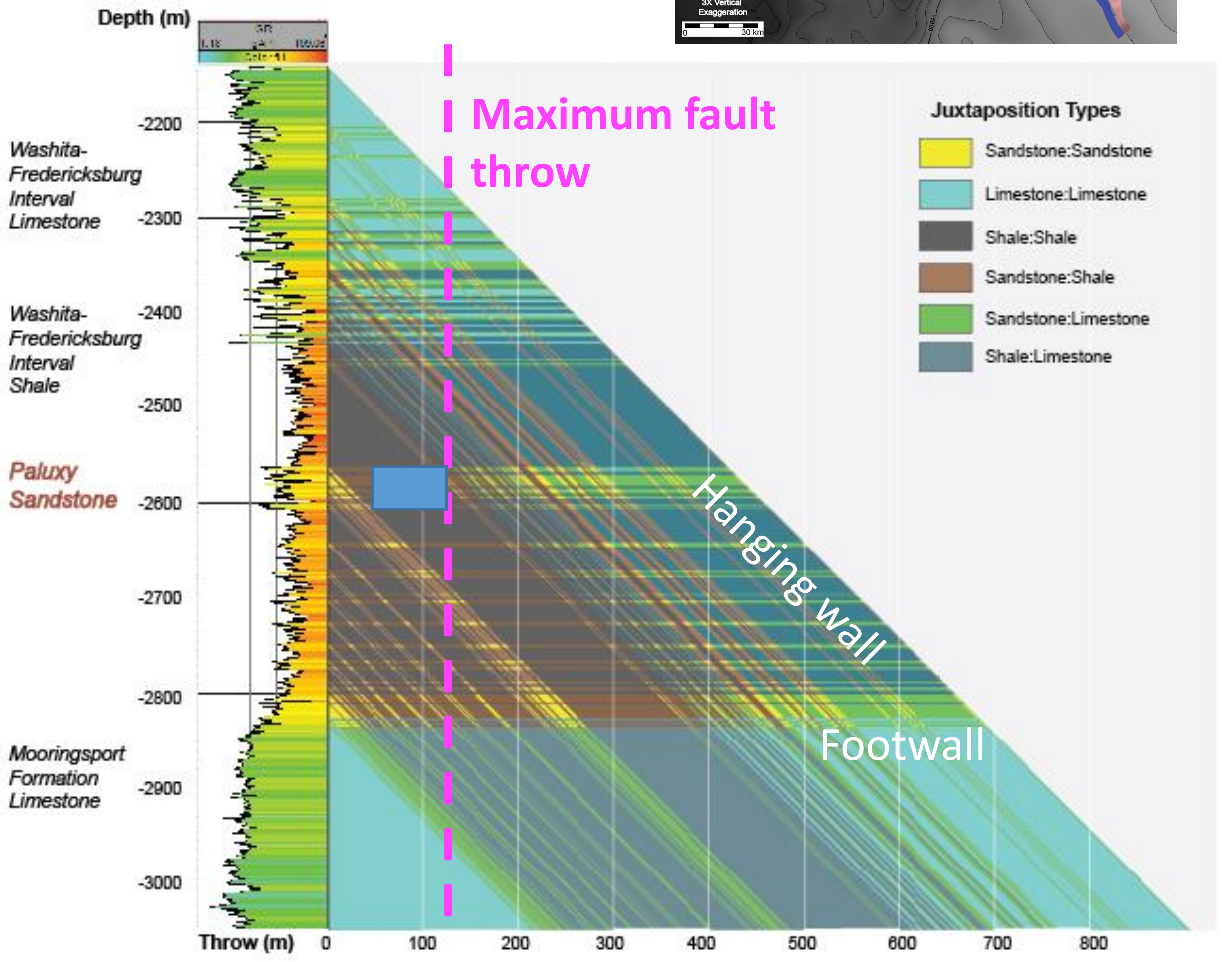


Shale Gouge Ratio

$$\mathrm{SGR} = \frac{\sum(Shale\ layer\ thickness * Clay\ percentage)}{Fault\ throw}$$

SGR values less than 15-20% contain a high risk of leakage.

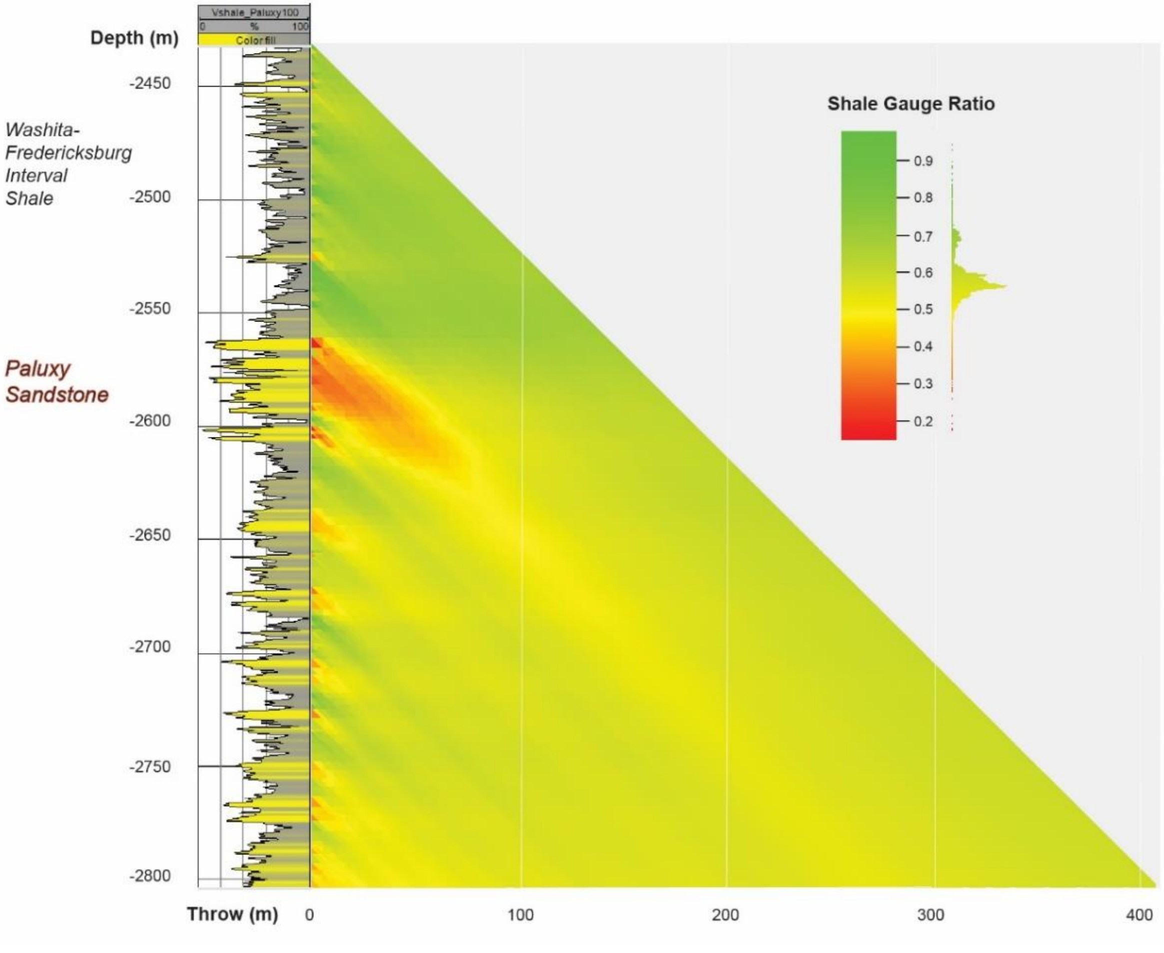
(modified from Færseth et al., 2007; Yielding et al., 1997, 2002)



1D Juxtaposition Diagram (Well G02502)

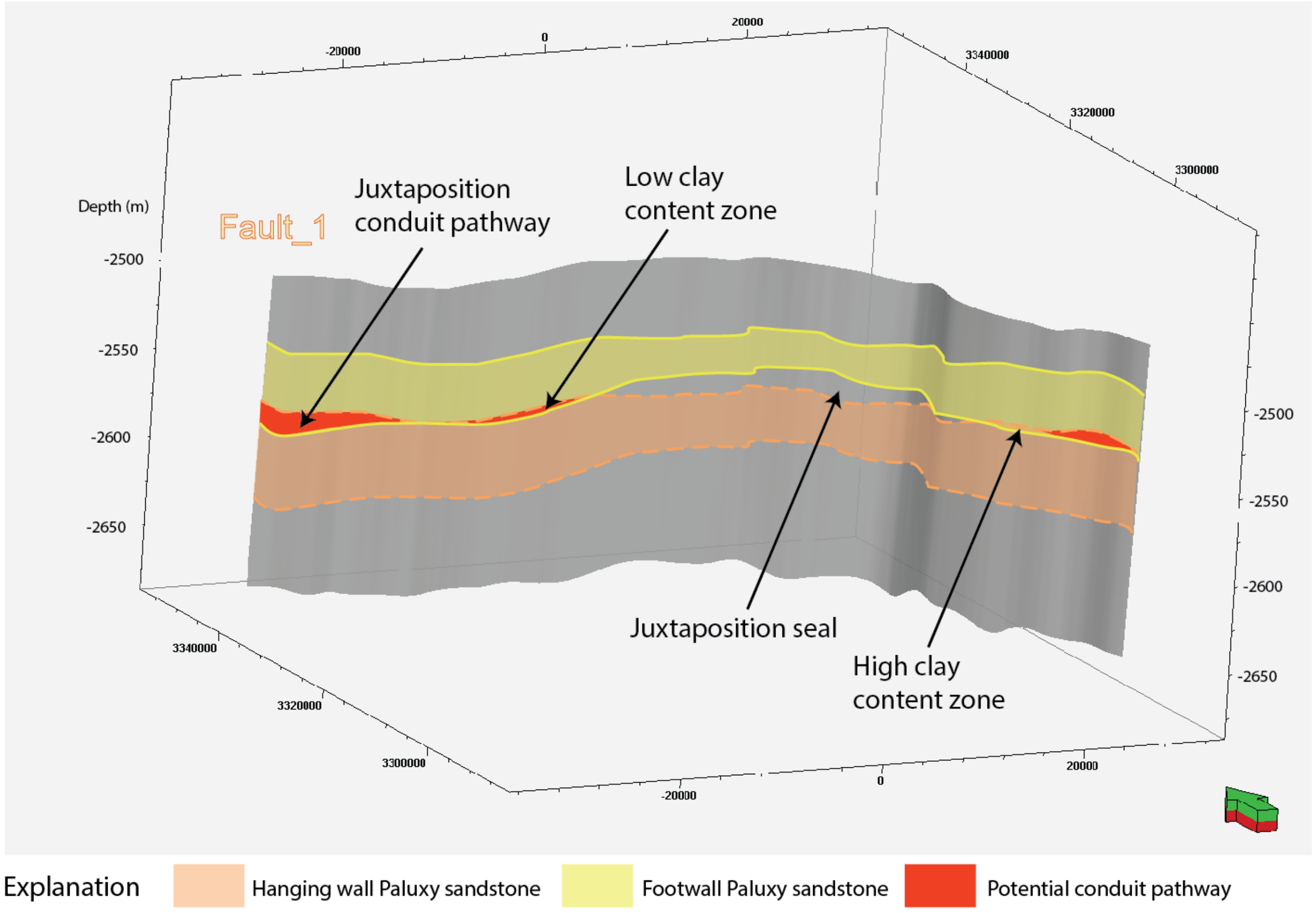
Fault Seal Analyses

Shale Gauge Ratio



SGR values (Well G02502)

Model of Fault Sealing Properties



Summary

- Geologic framework highly variable within and among study regions (salt basin, stable shelf).
- Multiple faults in the salt provinces cut Cretaceous reservoirs and seals.
- Fault slip tendency is minimal, whereas fault dilation tendency is significant.
- Fault seal analysis indicates that risk of migration along and across faults is greatest where sandstone-sandstone juxtapositions are developed and least where shale-sandstone juxtapositions are developed.
- Favorable CO_2 injection sites are in hanging-wall rollover folds and in footwall uplifts that are safeguarded by shale-sandstone juxtapositions.
- Ongoing research is focusing on geomechanics, pressure, and flow simulation of the potential reservoirs and associated seals.

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Thank You!!!