Pressure Space:
A Step Towards Realistic Capacity Maps

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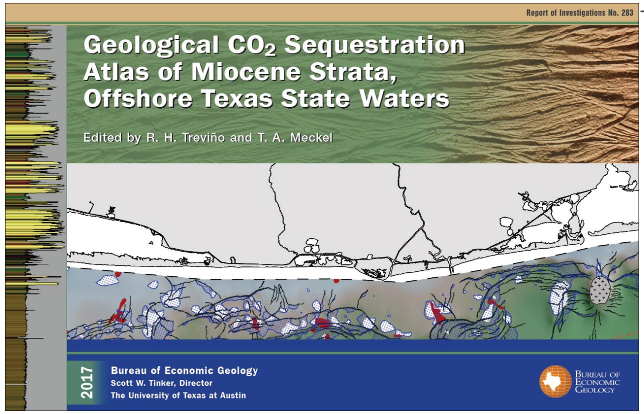
Static Capacity

Great for showing big numbers….



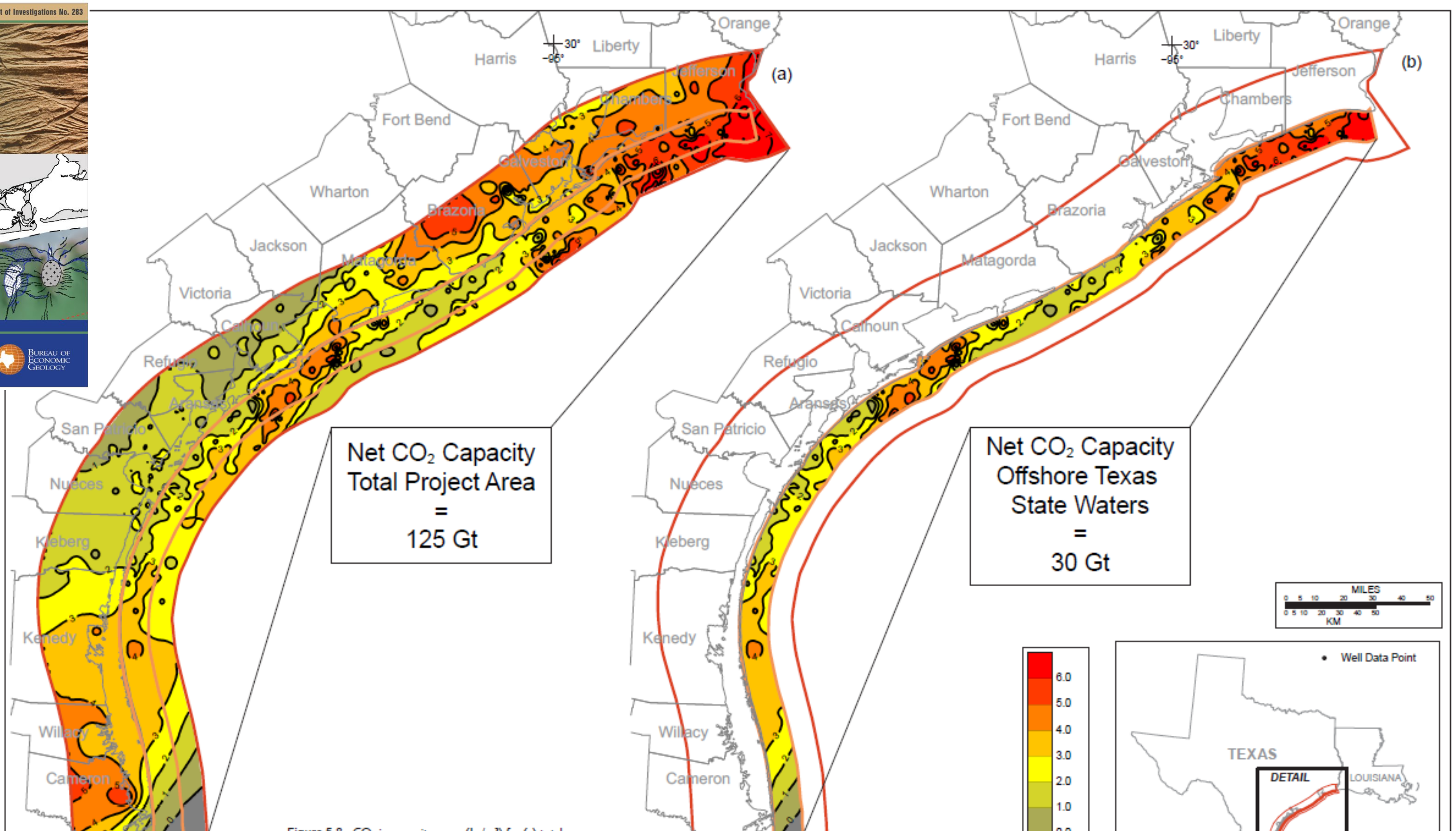


Figure 5.8. CO_2 isocapacity maps (kg/m³) for (a) total study area and (b) OTSW. Net capacity method of Wallace et al. (2014) was utilized.

…but not realistic ones

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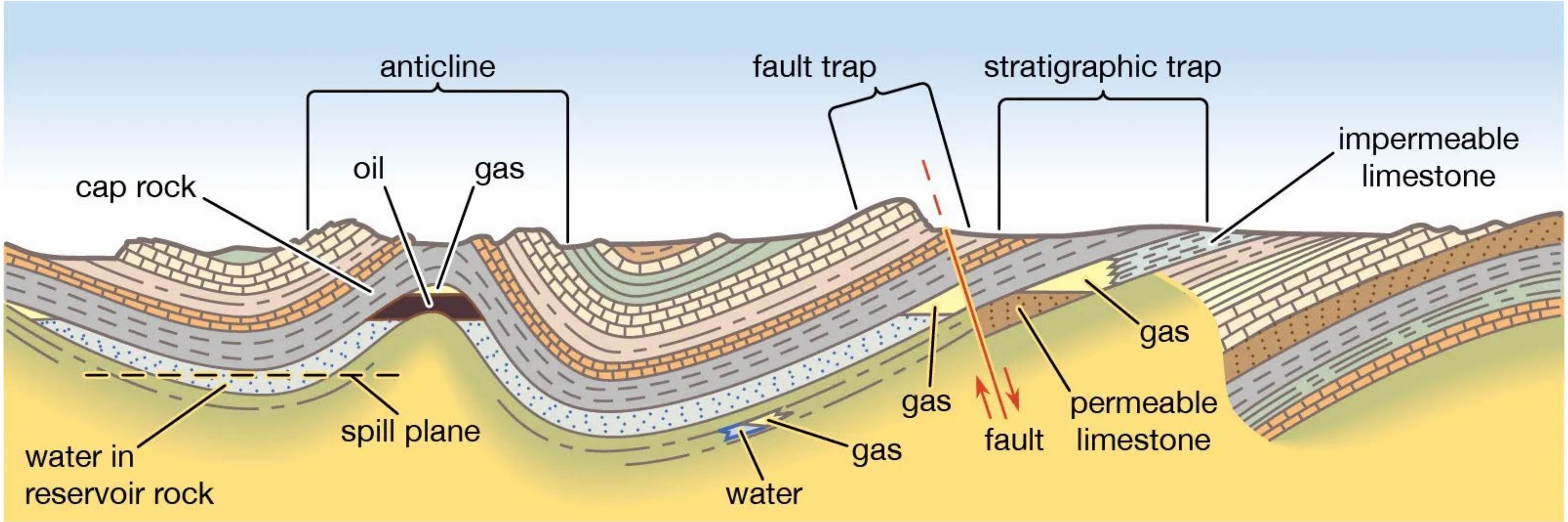
It Works for Oil and Gas…



…Not So Much for CCS

- Injection at industrial rates
  - Sweep efficiency is highly uneven
  - Saturation is unpredictable
- Subsurface pore space is already full
- Injection requires making space for more fluid
  - Raise the land surface—real but small effect
  - Displace pre-existing fluids
    - Only creates space if you can displace to ground surface or seabed
    - In sealed reservoirs, displacement is limited
  - Dissolution—real but limited
  - Compress rock and pre-existing fluids
- **Pressure rise is inevitable and the key limit**

Hovorka (2011)

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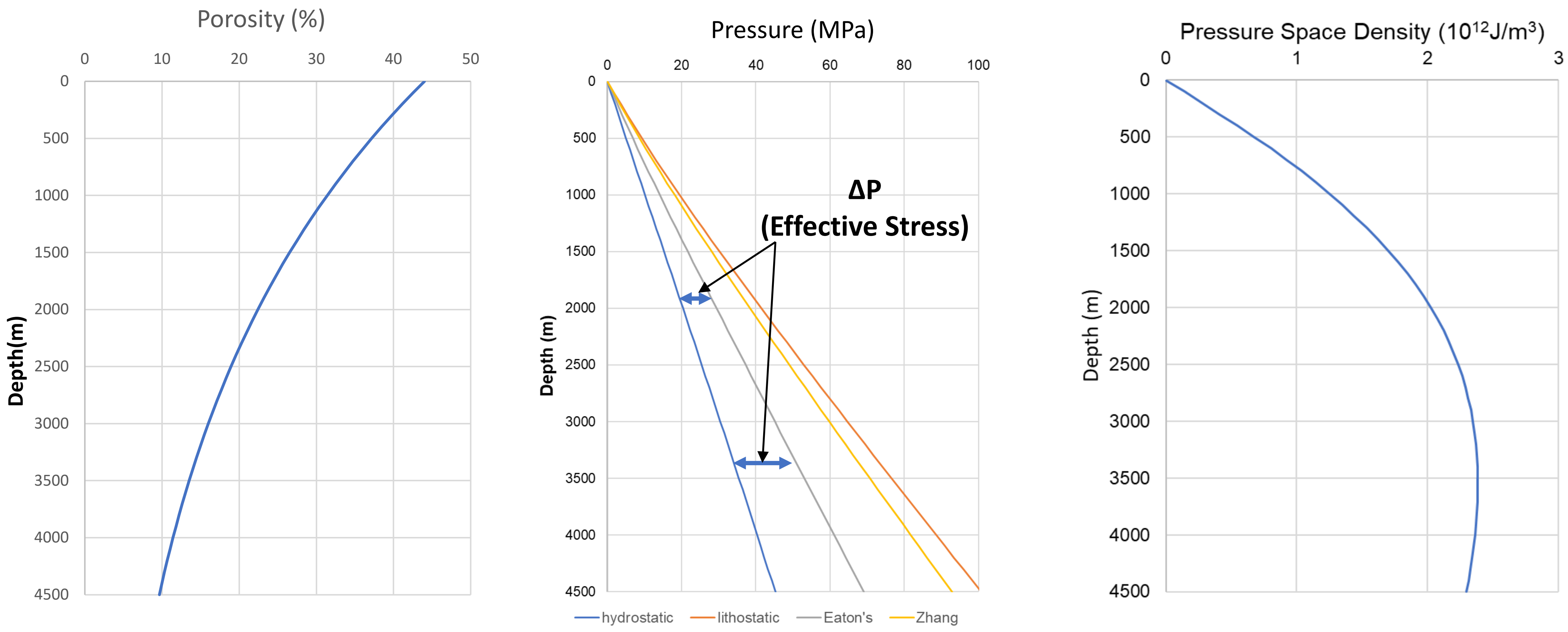
Pressure Space

Pressure space = (Pore Volume)(Allowable Pressure Increase)



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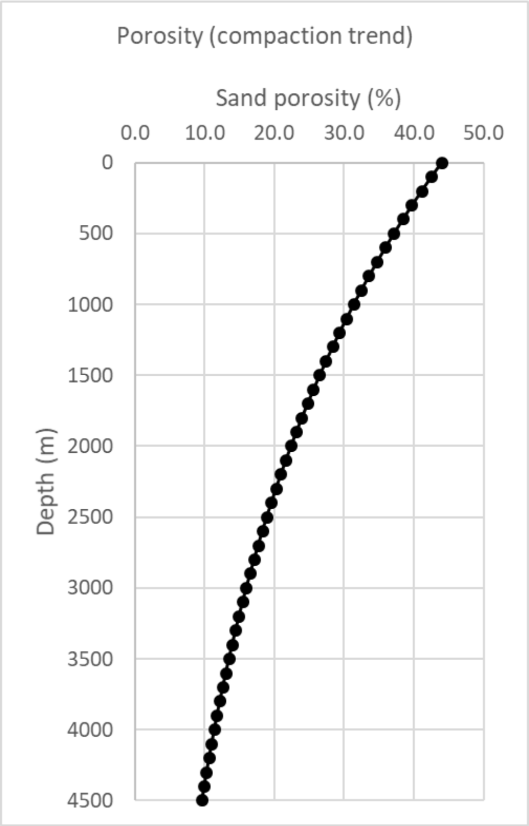
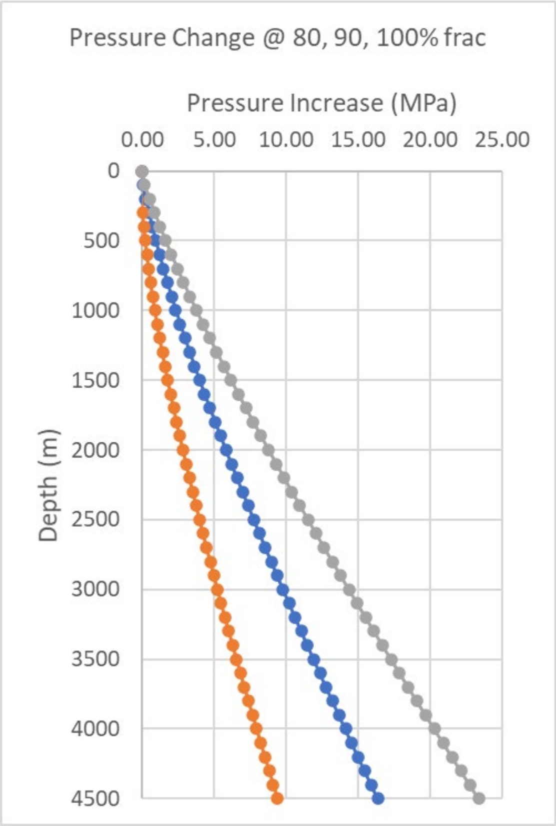
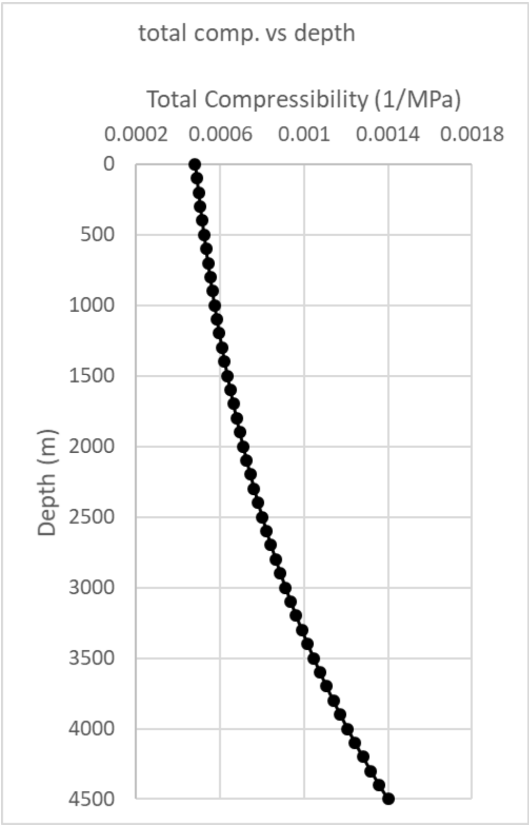
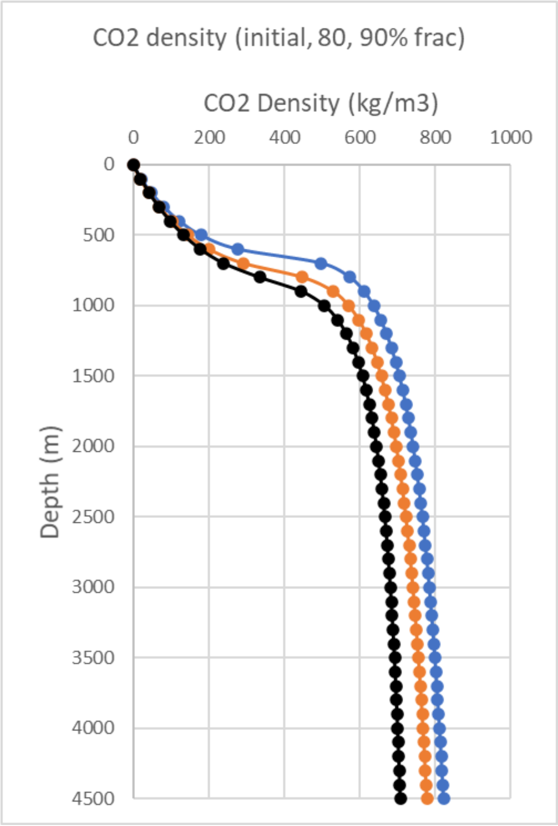
Calculating Capacity

Capacity= (Pore Volume)(Allowable Pressure Increase)(Total Compressibility)(CO_2 Density)









<u>Final Pressure (% of frac)</u>

● Hydrostatic or N/A ● 80 % ● 90 % ● 100 %

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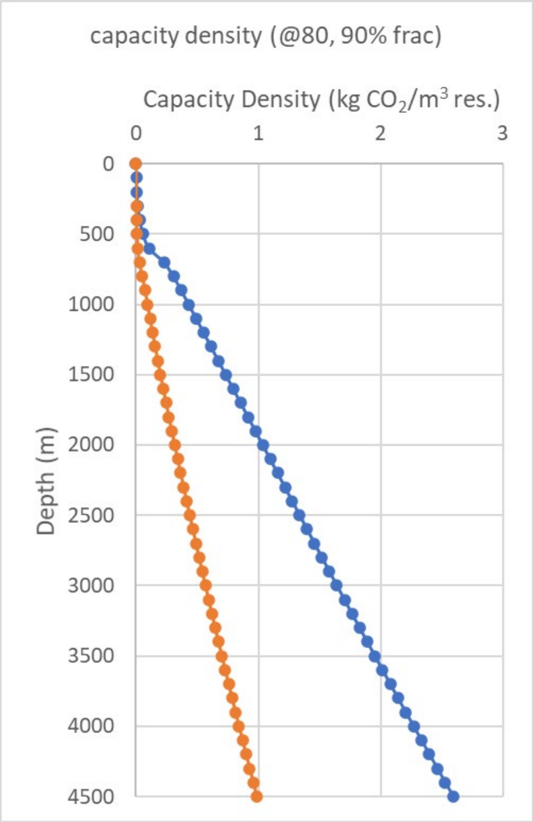
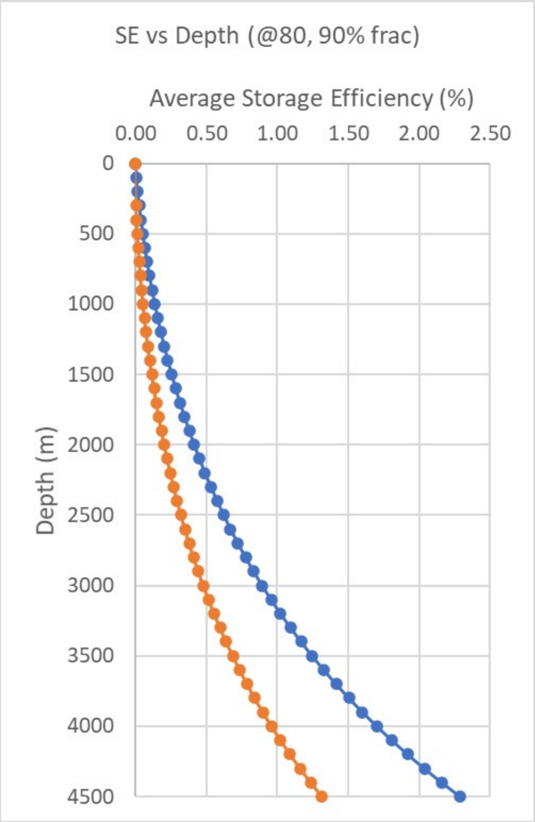
Pressure-Based Capacity vs Depth

Capacity= (Pore Volume)(Allowable Pressure Increase)(Total Compressibility)(CO_2 Density)





Final Pressure (% of frac)

80 % 90 %

- Capacity is depth dependent
  - Deeper pore space has greater capacity than shallow
- Below supercritical, capacity is a ~linear function of depth
  - Can use injection zone thickness and midpoint pressure, compressibility, density values to calculate capacity
- Same algebra can be applied to map-view grids

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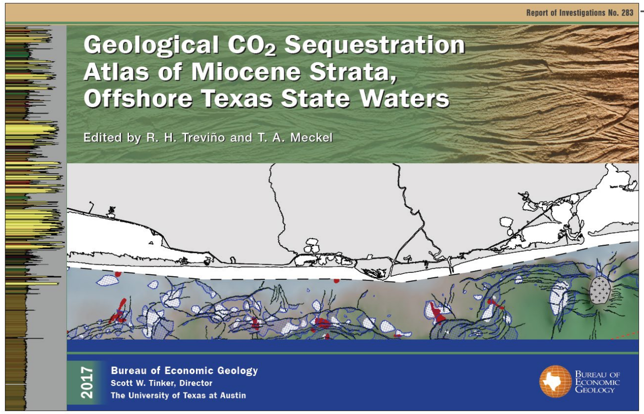
Mapping Example: Gulf Coast Miocene



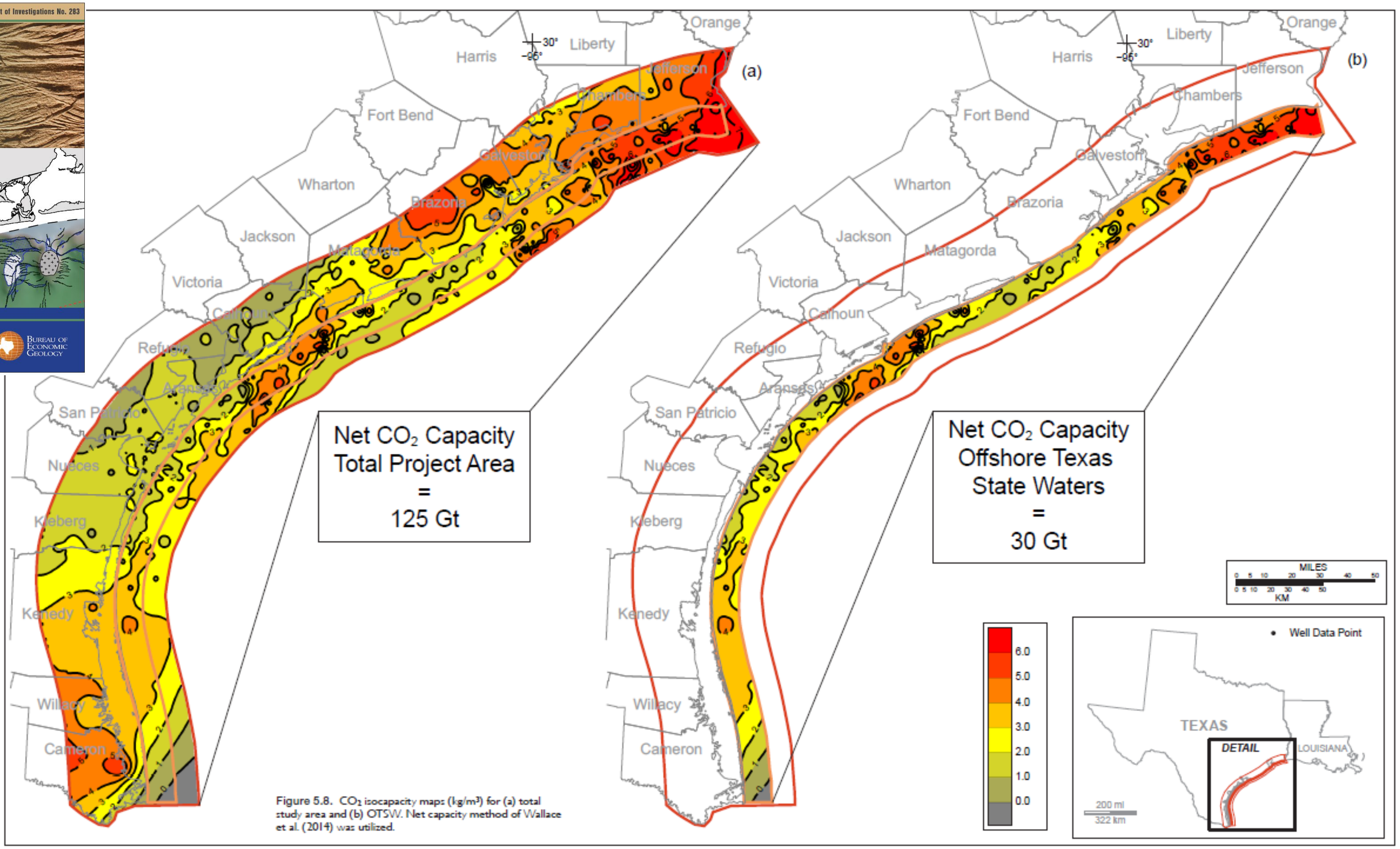


Figure 5.8. CO_2 isocapacity maps (kg/m³) for (a) total study area and (b) OTSW. Net capacity method of Wallace et al. (2014) was utilized.

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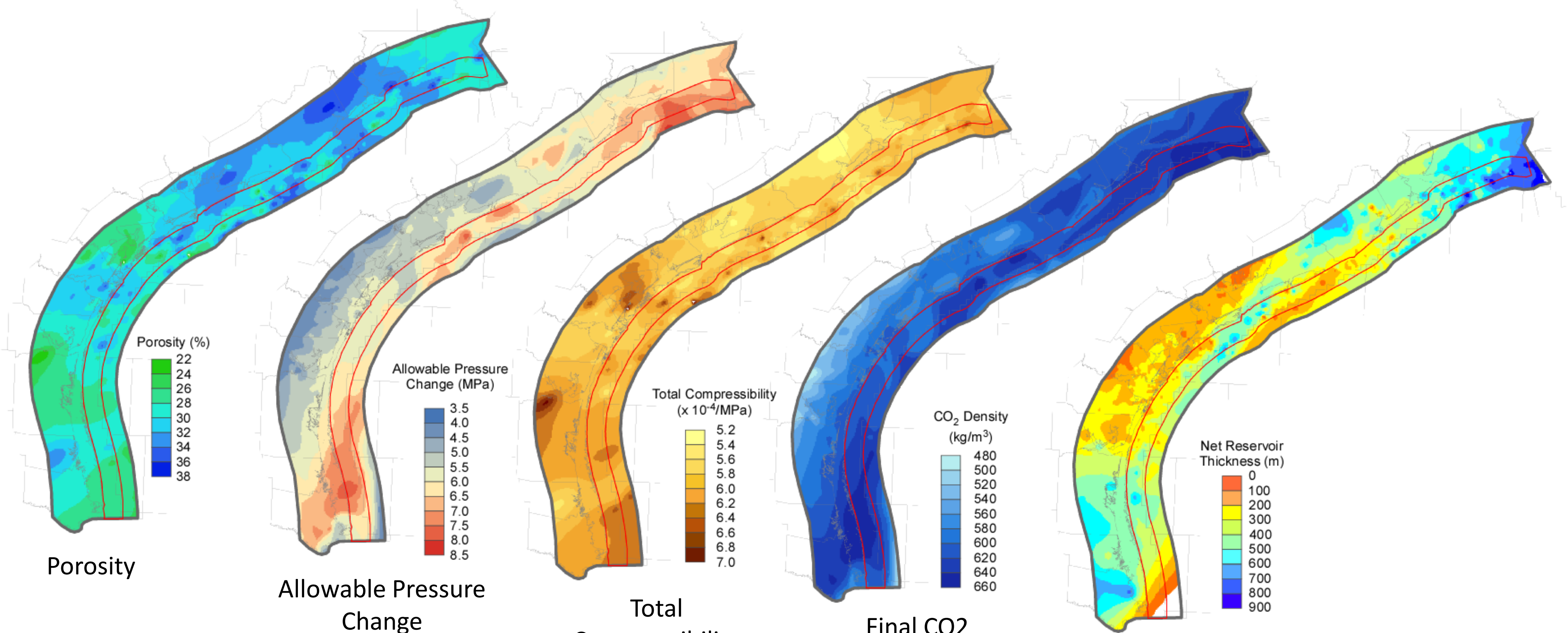
Gulf Coast Miocene



Porosity

Allowable Pressure Change

Total Compressibility

Final CO2 Density

Net Reservoir Thickness

Original data courtesy of Dave Carr

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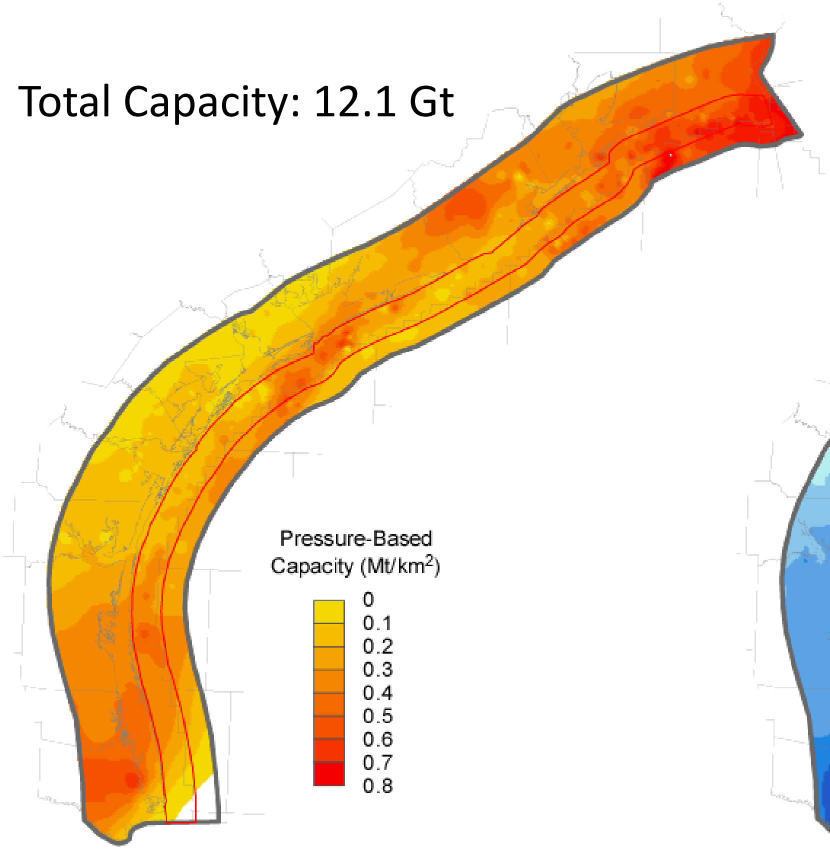
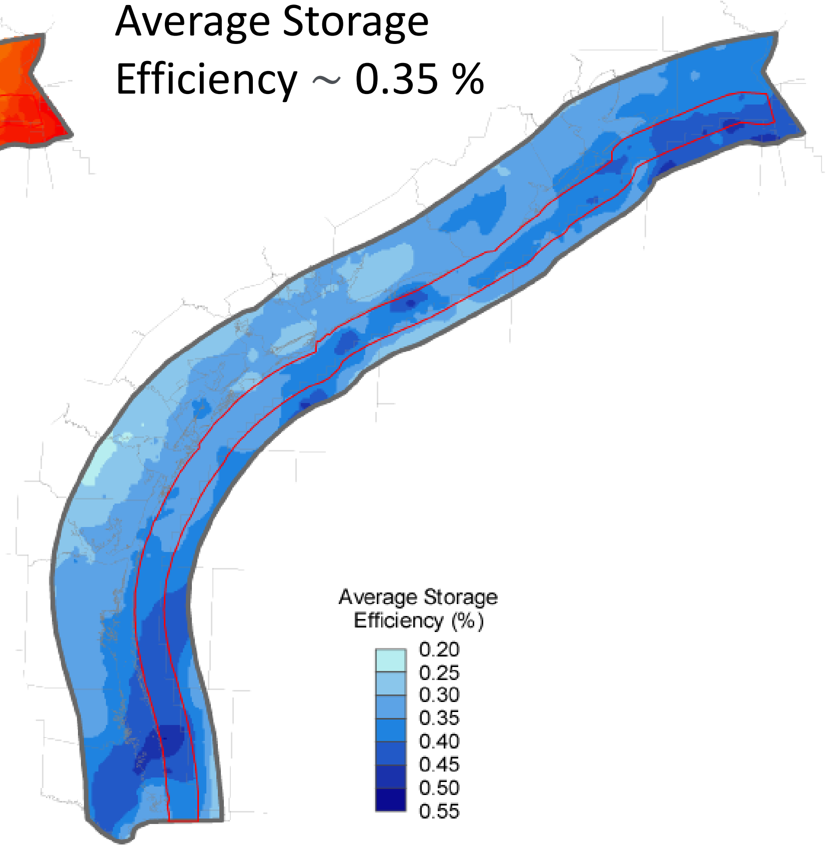
Pressure-Based Capacity

Total Capacity: 12.1 Gt



Storage Capacity
(Mt/km^2)

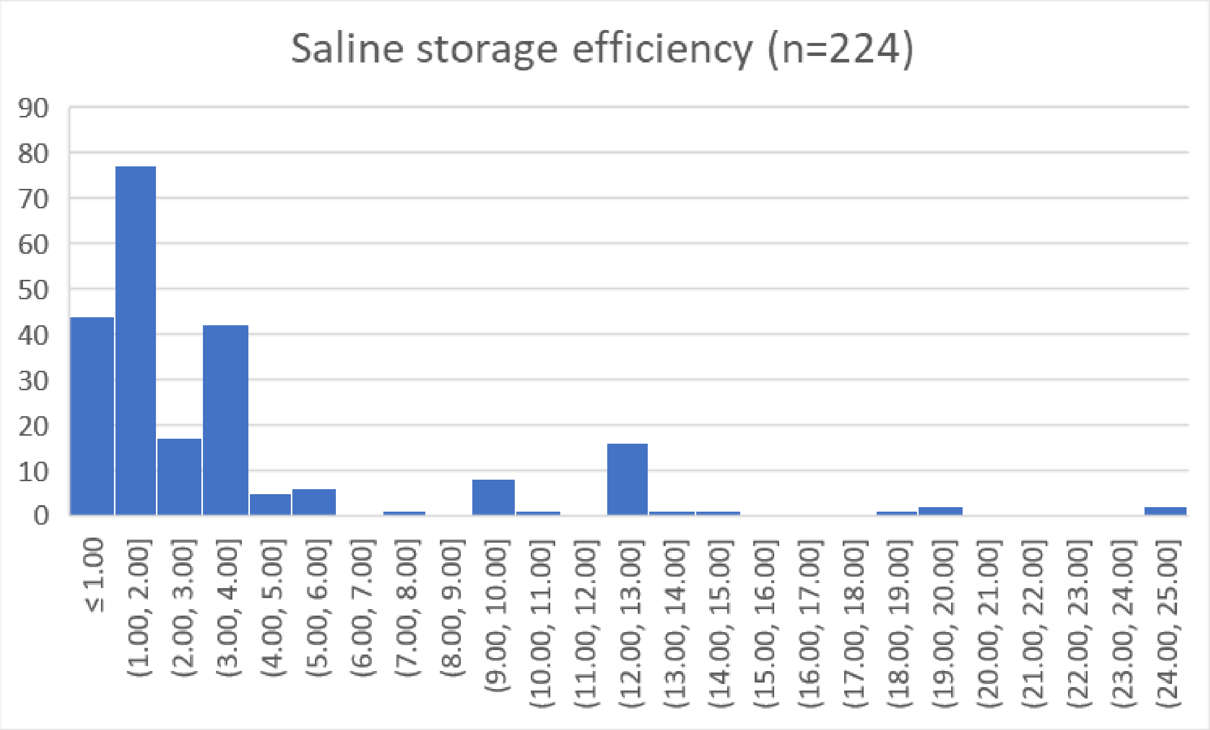
Average Storage
Efficiency ~ 0.35 %



Average Storage
Efficiency (%)

Storage Efficiency Comparison

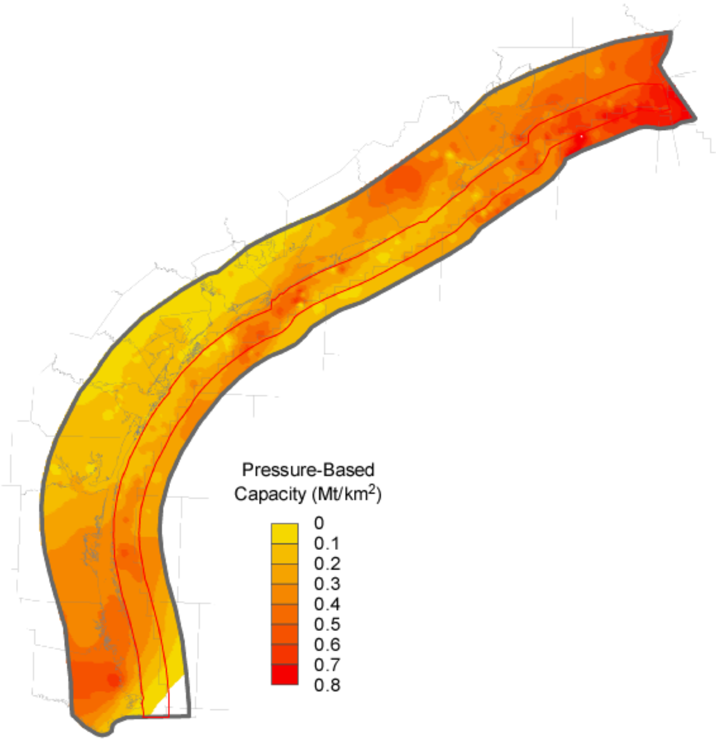
CO_2 Storage Resource Catalog



(OGCI, 2023)

Most published SE numbers require borrowing pressure space from neighbors

Thoughts and Next Steps



Total Capacity: 12.1 Gt

- Powerful tool—basis for next generation of maps
- But…
  - Assumes final pressure is 90 % of frac
    - It's capacity but maybe not achievable capacity
  - Also takes "net reservoir" at face value
    - Non-net does not contribute at all here
    - Silty interbeds and seals might contribute significant pressure space over 1-3 decades
  - This is pressure-based capacity only
    - At this scale of SE, dissolution could be a significant contributor
    - Reservoir brine can dissolve ~ 5 % of its mass in CO_2
    - If CO_2 contacts 10% of the pore space (filled with unsaturated brine), dissolution could add another ~0.5 % SE (double pressure alone!)
- Not the final word
  - Boundary conditions? How much pressure space can 1 well access?
  - Contributions from dissolution and non-net reservoir?

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