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Low-BTU Hydrocarbon Fields as Natural Analogs for Geologic CO_2 Storage

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Low-BTU Field

- Low-BTU gas defined as <950 BTU/scf
- Heat content lowered by high percentage of non-hydrocarbon components (CO_2, N_2, H_2S, etc.)
- For this study, we have identified fields that have >10% CO_2, and >10% CH_4

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Rationale

- Petroleum and CO_2 are buoyant fluids that behave similarly in the subsurface
- Traps that have contained petroleum on geologic time scales are ideal storage sites for CO_2
- Therefore, we need to look at petroleum fields with high CO_2 concentrations as they are natural analogs for such storage.

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Related Work

- "Pure-CO_2" gas fields
  - Utah Geological Survey (Allis et al.)
  - Advanced Resources International
  - NASCENT

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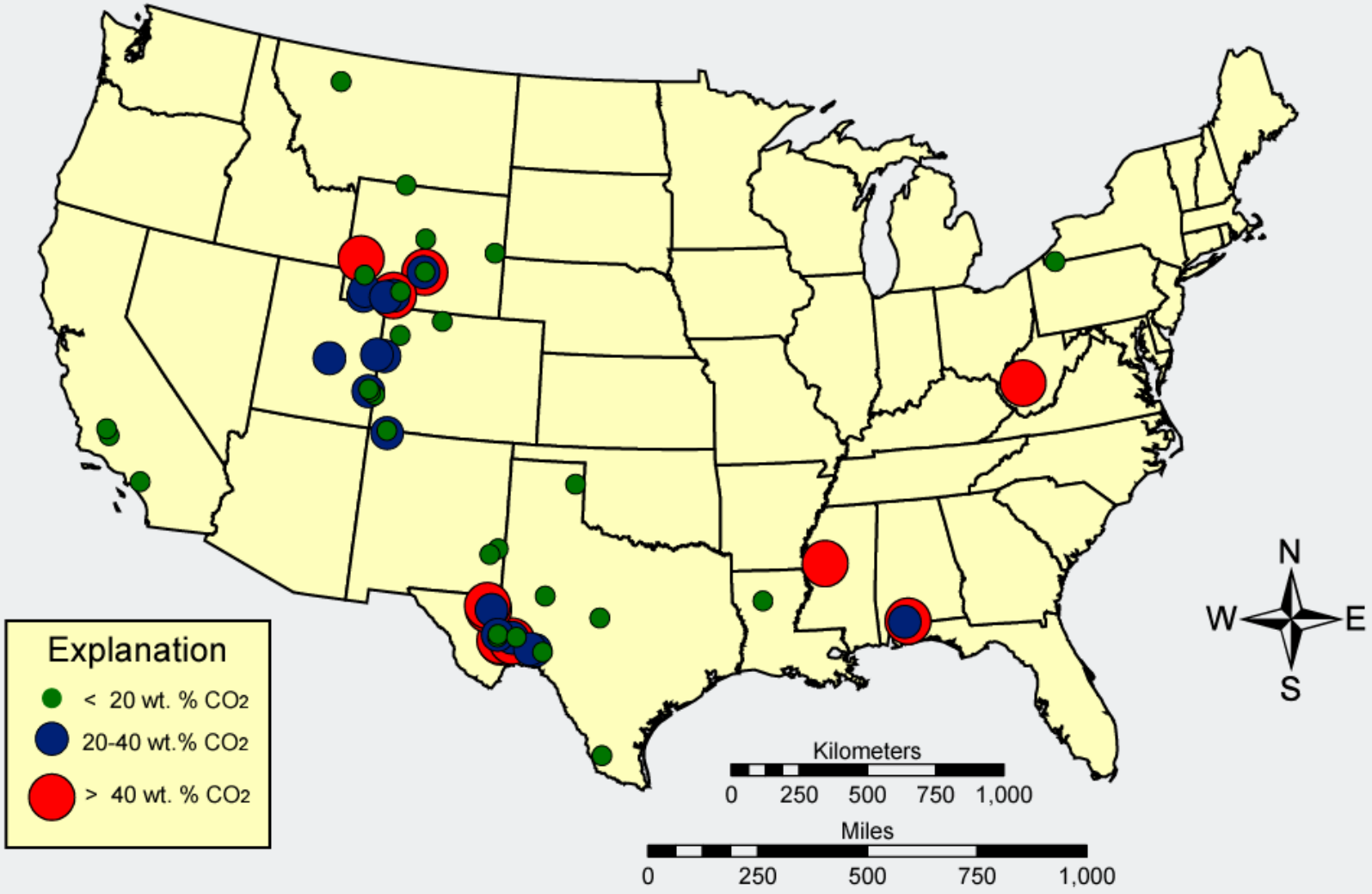
High Carbon Dioxide / Low BTU Natural Gas Fields of the United States



Total CO_2 System

- Based on Total Petroleum System, which ties together the source with the ultimate migration of the hydrocarbons into traps
- If we can identify the source of CO_2 and the timing of generation of CO_2, then we can:
  - Determine how long CO_2 has been in reservoir
  - Identify diagenetic changes in reservoir and along migration pathway that may have been caused by CO_2
  - Learn more about CO_2 migration mechanisms and pathways

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Natural CO_2 sources in the subsurface

- Oxidation of organic matter/hydrocarbons
  - Thermal degradation of organic matter
  - Sulfate Reduction
    - Bacterial
    - Thermochemical (>80°C)
- Reaction between clays and carbonates (>100°C)
- Contact Metamorphism (Thermal decarbonation)
- Volatiles from cooling magma

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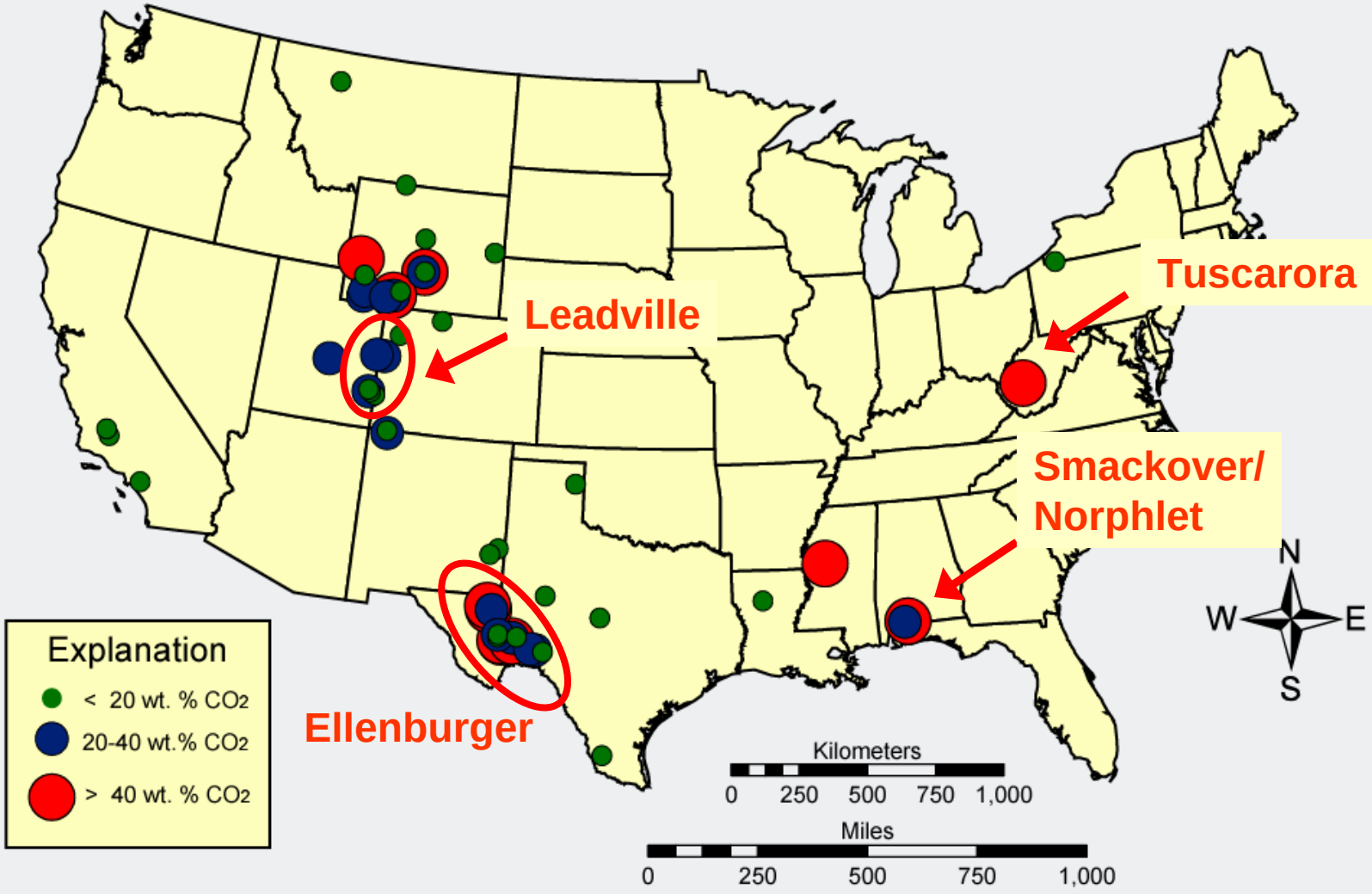
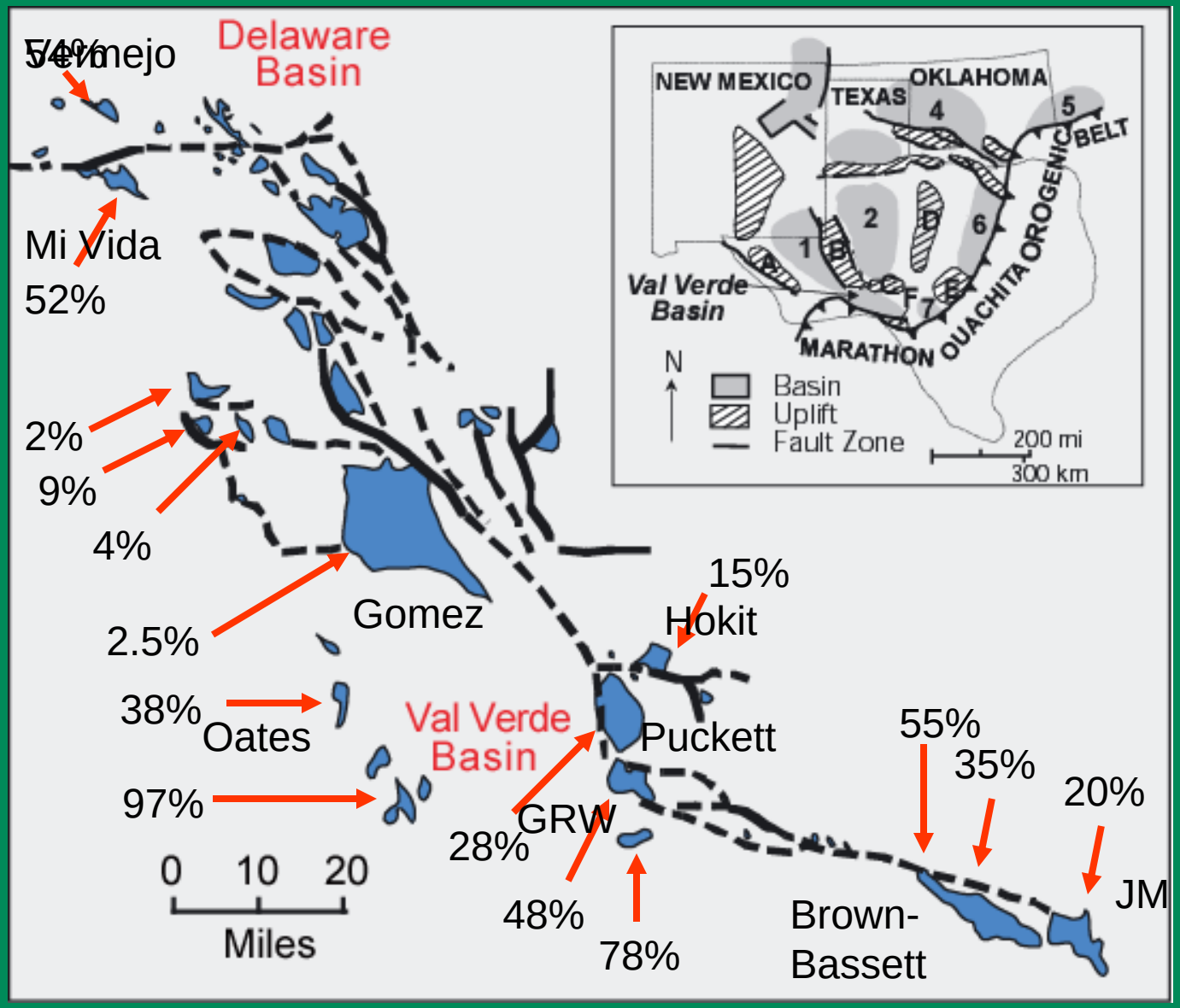
High Carbon Dioxide / Low BTU Natural Gas Fields of the United States



Ellenburger Fields, West Texas



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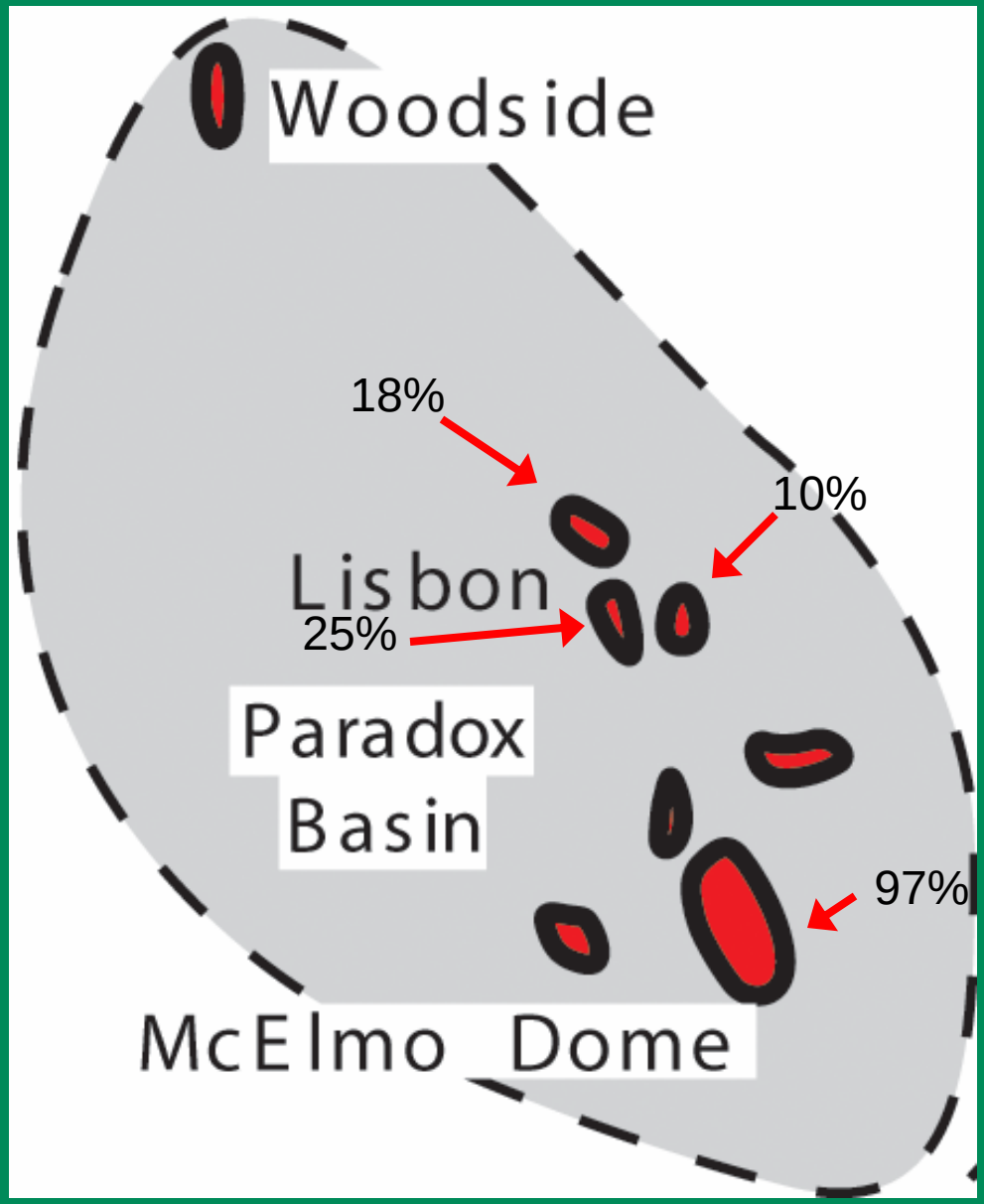
Leadville Fields



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CO_2 System Examples

Host	Rock Type
Ellenburger Formation	Dolomitic Limestone
Leadville Limestone	Limestone
Smackover Formation	Dolomitic Limestone, Evaporites
Norphlet Formation	Sandstone

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CO_2 System Examples

Host	CO_2	H_2S
Ellenburger Formation	2-57% (97%)	0%
Leadville Limestone	10-25% (99%)	0%
Smackover Formation	40%	21%
Norphlet Formation	45%	5%

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CO_2 System Examples

Host	Predominant Source
Ellenburger Formation	Magmatic
Leadville Limestone	Limestone Decarbonation
Smackover Formation	Thermochemical Sulfate Reduction
Norphlet Formation	

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Usefulness of the TCS

- Storage duration
  - Ellenburger Fields, West Texas:
    - CO_2 in southern section of the Val Verde Basin was at least in part from a magmatic source (Ballentine et al., 2001).
    - The CO_2 entered the reservoir 300 Ma, and has remained in the traps since that time
- Injection simulation
  - Smackover and Norphlet Fields:
    - CO_2 formed during TSR of gas condensates
    - CO_2 formed locally, did not migrate long distances
    - Analog for direct CO_2 injection into Petroleum traps

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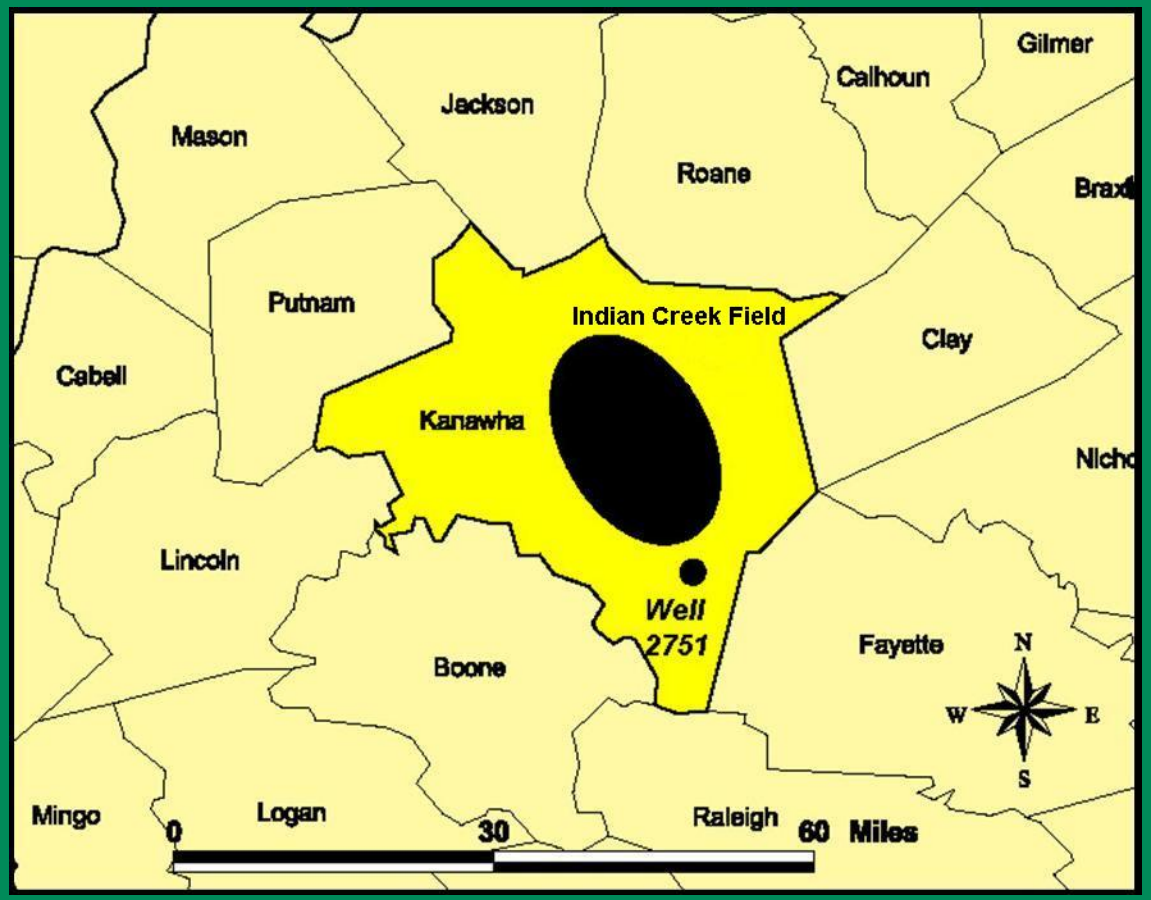
TCS application: Indian Creek Field



Main Reservoir: Tuscarora
Reservoir Depth: 6600 ft.
Discovery 1975
34 producing wells

Gas composition:
remainder CH_4
26.5-83%CO_2 (65% mn)
0% H_2S

Prod. Reserves: 20 Bcf
Rem. Reserves: 40 Bcf

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Indian Creek Field

- Reservoir has evidence of an extensive fracture system
- Most intergranular porosity has been occluded by quartz cement
- However many “pockets” of primary intergranular porosity remain
- Fractures connect these pockets, and were likely the conduit by which fluids entered the reservoir

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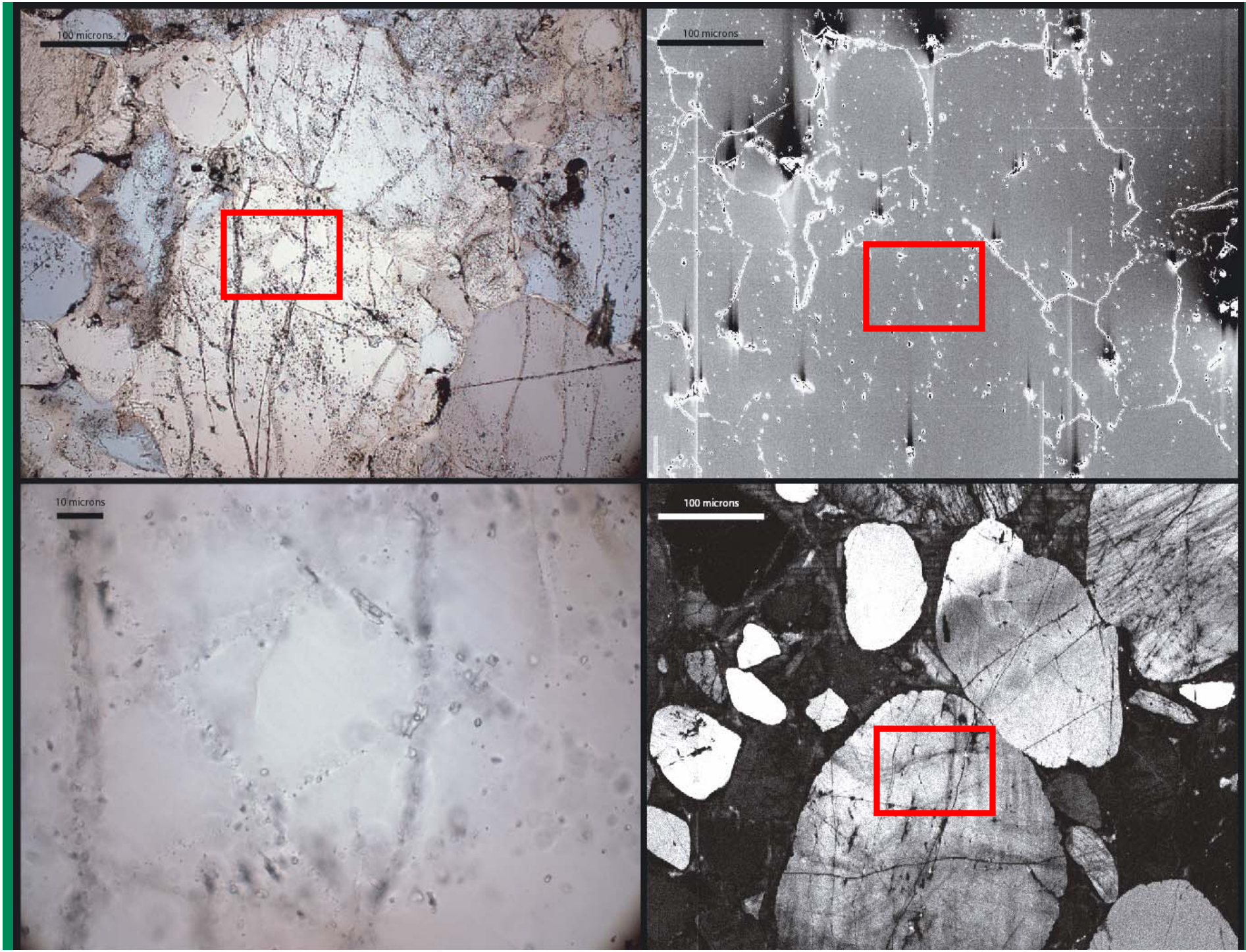
100 microns
100 microns
10 microns
100 microns

Conclusions

- High CO_2 gas fields scientific value as analogs for both saline aquifer and depleted gas field storage:
  - Demonstrated long term CO_2 storage
  - Serve as a “natural laboratory”. Reactions that have occurred within these fields are not possible in laboratory environments
  - They also can serve as storage sites
- Total CO_2 System provides a way to apply information gained from these natural analogs to CO_2 storage issues

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For more information

- USGS Geologic CO_2 sequestration project page:

  http://energy.er.usgs.gov/projects/co2_sequestration/co2_index.htm

- GASIS
  - Can get from NETL, from their publications website

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