WINDY COVE ENERGY II

CO_2 as a Commodity for Realizing the Potential in Unconventional Production Strategies of Conventional Reservoirs

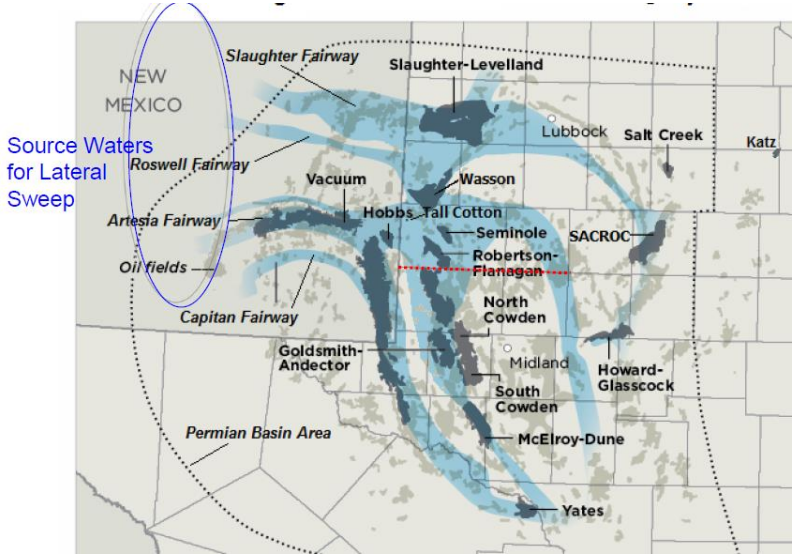
September 26th, 2019

What does that long title mean?

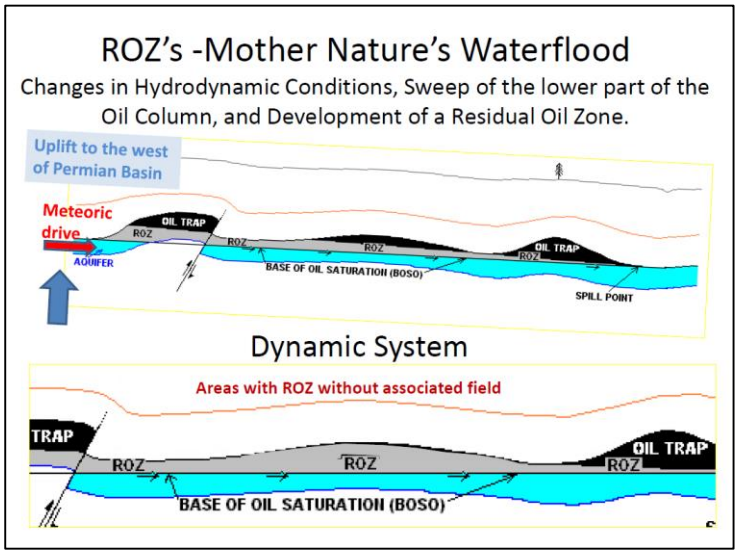
- It means,
  - Injecting CO_2, or a mix of CO_2 and produced gas, into areas of horizontal well development in conventional reservoirs (outside of conventional waterflood development)
  - Mobilizing a secondary oil bank not realized from frac'ing methods
  - Sequestering CO_2 long term
- Two options for implementation
  - Producer huff-and-puff
  - Dedicated CO_2 injectors
- Successful projects already underway in unconventional plays:
  - Eagleford (EOG, Marathon) – produced gas huff-and-puff
  - Bakken – (Hess) – produced gas huff-and-puff
  - Permian Wolfcamp – (Oxy) – CO_2 huff-and-puff

What is the Horizontal San Andres Play?

- Drilling horizontal wells outside of traditional anticlinal structures in the "fairways" between existing fields
- Use unconventional completion strategies to produce
- San Andres reservoir has conventional rocks properties
  - Porosity in the 6-8% range
  - Millidarcy permeability
- Water disposal is critical to economic success
  - High fluid volumes, with a 5-20% oil cut



Melzer & Trentham, SIPES, April 2016



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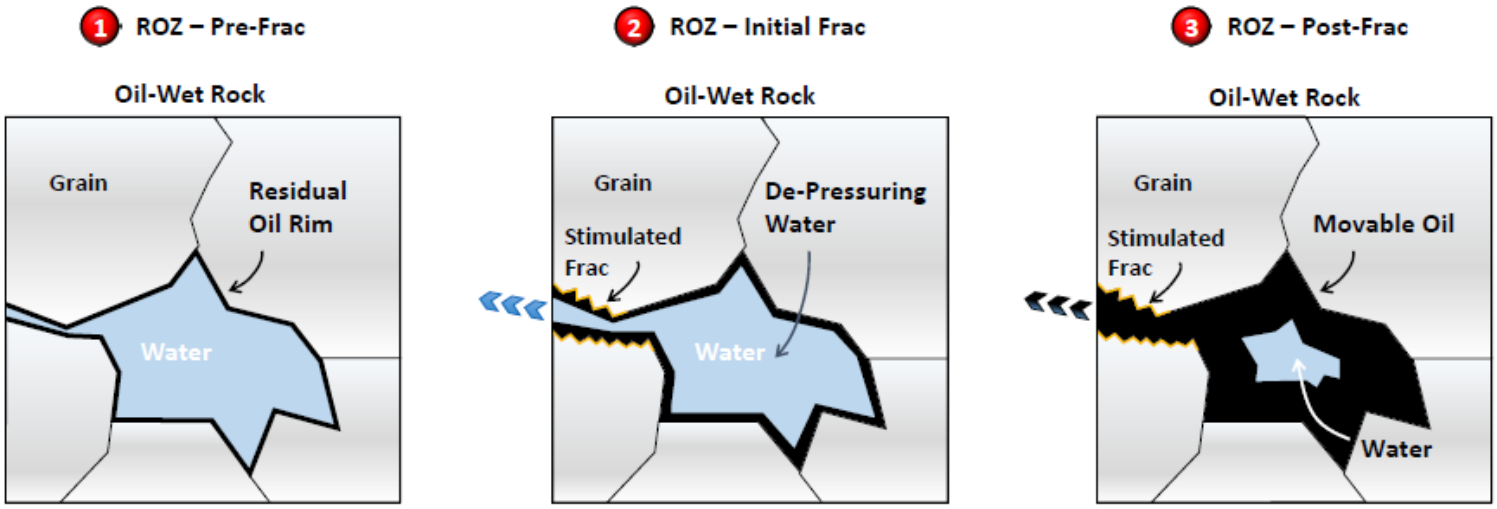


Imagine an ROZ pore space....

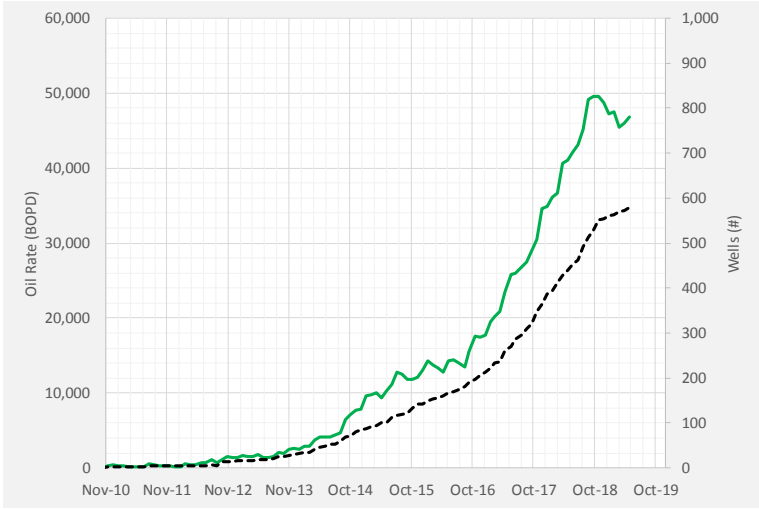
1. Movable hydrocarbons have been swept leaving water plus ***residual oil molecules*** clinging to the rock → The resultant pressure of the incompressible water in the pore is so great that the compressible oil molecules can't move
2. For oil to mobilize, the pore must first be ***de-pressurized*** resulting in ***high initial water production***
3. With some of the incompressible water removed, oil molecules expand, coalesce, & release from the pore surface → The well then produces ***both*** oil and water

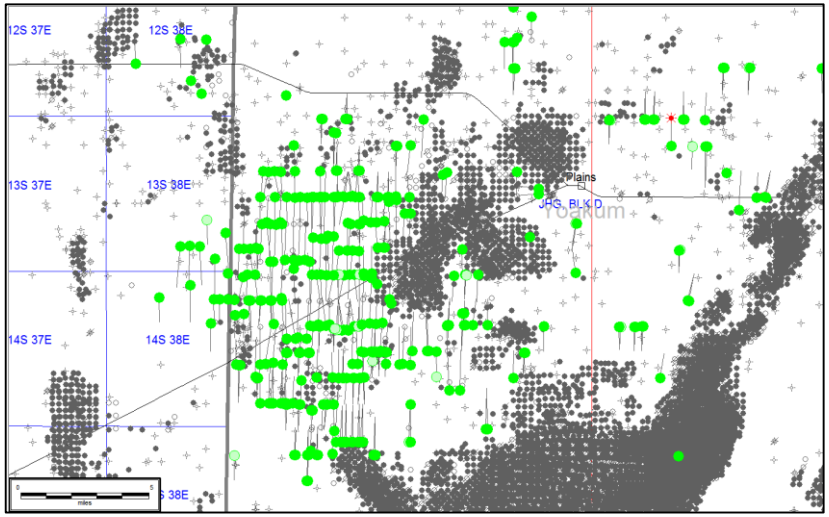
A horizontal well with a multi-stage frac expedites this de-pressuring process

Dec. 2017, CO_2-ROZ conference, Midland, TX

What is the Horizontal San Andres Play?

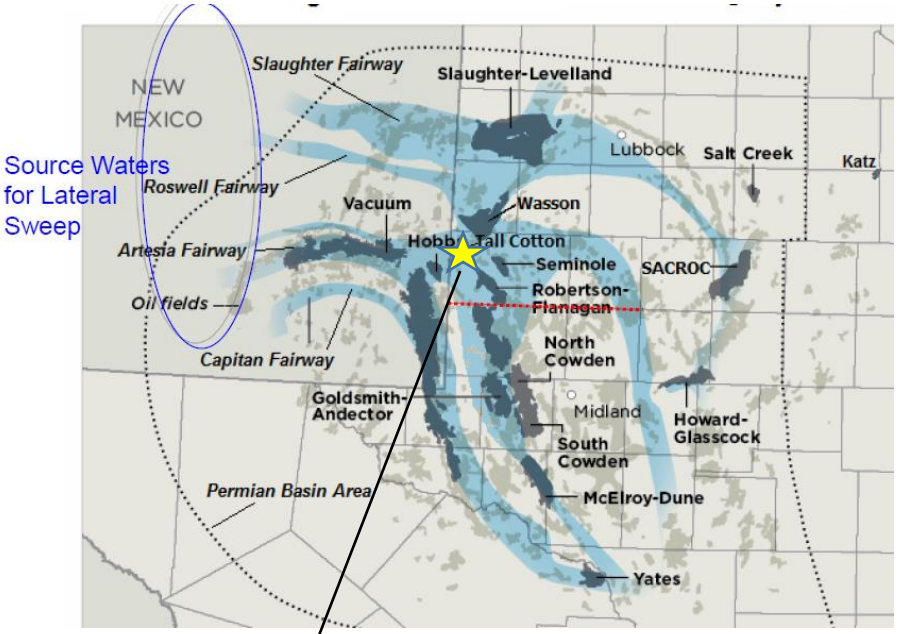
- As of May 2019:
  - > 40 companies
  - > 540 wells
  - > 46,000 BOPD
- Primarily focused in Yoakum, Gaines, Cochran and Andrews County
- Wide range of companies involved, small independents to super majors
- Low operating costs (~$10/BO) if you have water disposal





Why the Horizontal San Andres Play?

- San Andres dolomite
  - Most widely CO_2 flooded rock in the world
  - Proven response to CO_2 injection
  - Proven ability to sequester gas
  - Demonstrated results flooding the ROZ fairway (KM-Tall Cotton Field)
- Permian Basin:
  - Has the knowledge, expertise and technical ability to implement EOR projects
  - Has the infrastructure for distribution



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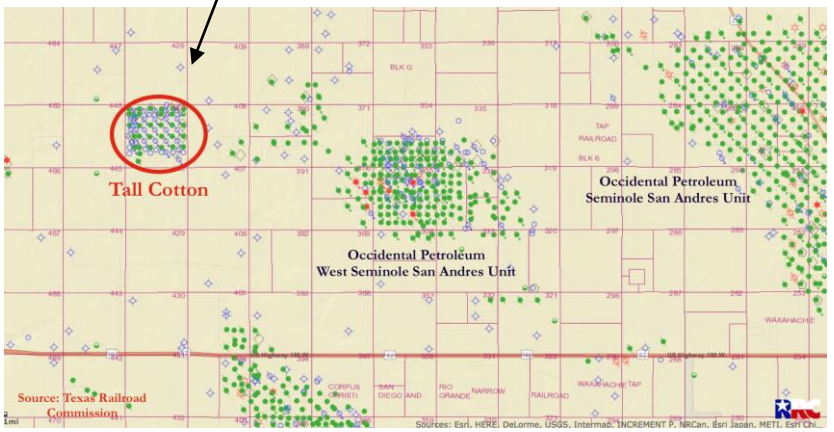
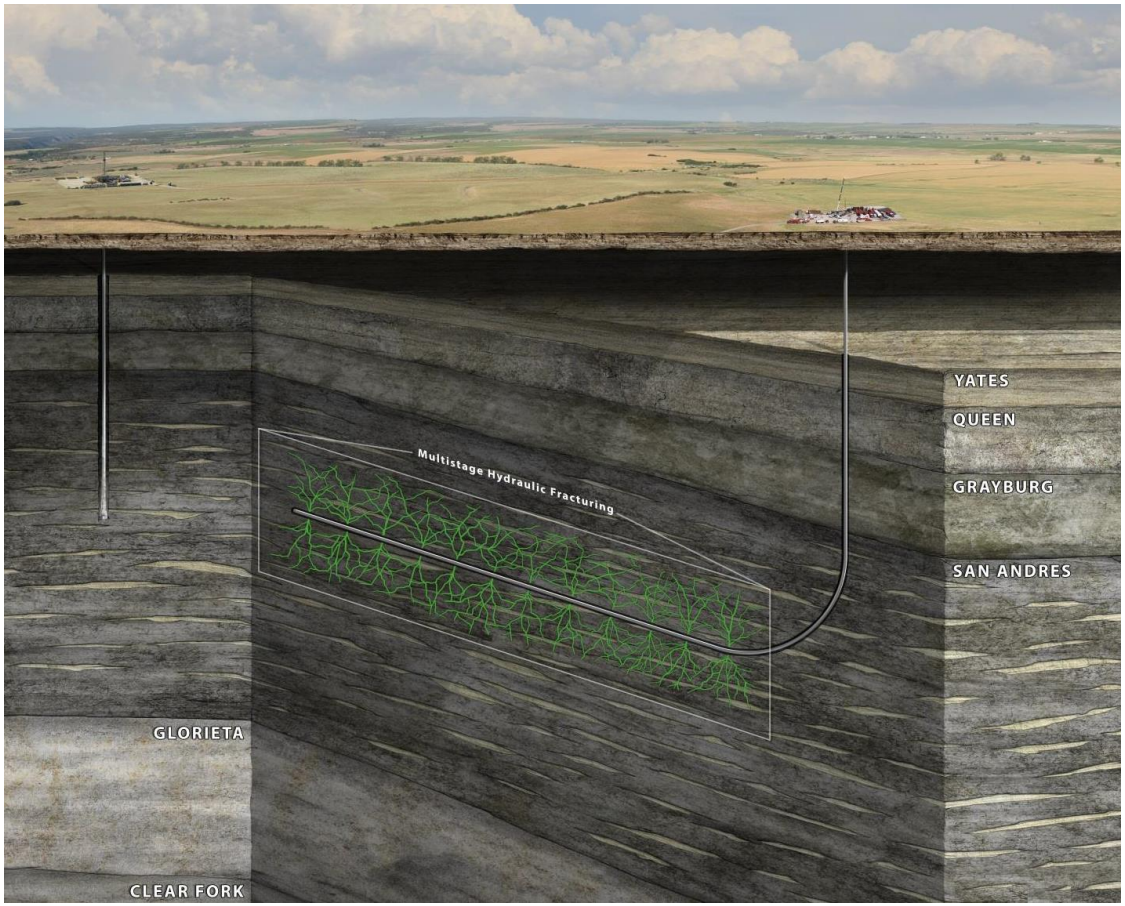


Horizontal San Andres Characteristics

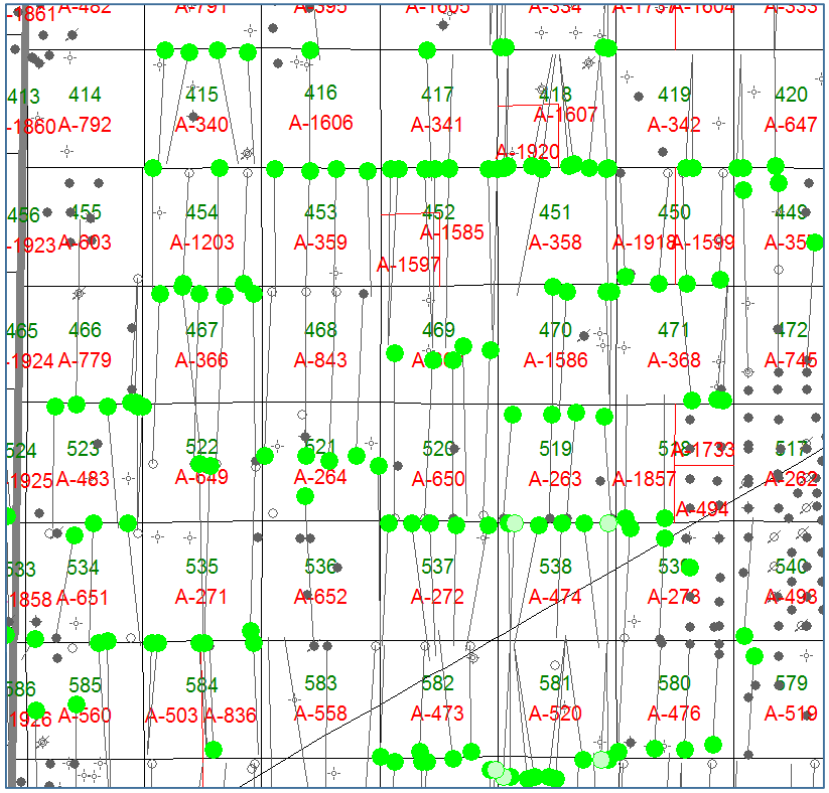
Well Characteristics

- Depth: ~5500’
- Length: 5000’-7500’
- Frac Stages every 200-300’
- Smaller proppant loads than unconventional plays
- D&C costs of $2.5-$3.0MM/well



Horizontal San Andres Characteristics

- Wells are typically developed:
  - North-South
  - 4-6 wells per section
  - Frac heights ~100ft
- EURs of 150-500+ MBO
- Ultimate recoveries in the 5-10% OIP range
- Waterflood is not an option
- CO_2 injection can recover another 25-30% of the OIP!



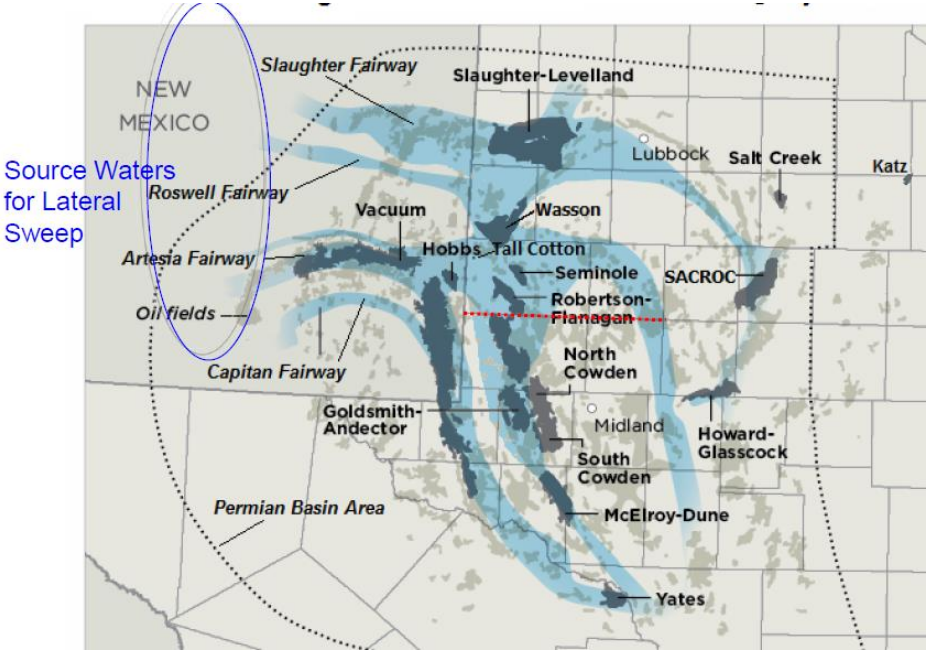
Size of the Prize (big picture)

- Roughly ~4MM acres of San Andres fairway (light blue)
- Assuming:
  - Φ = 6%
  - S_o = 40%
  - h = 100 ft

  OIP = 59,580 MMBO

  REC. OIL = 14.9 MMMBO!

- At a net utilization rate of 6 MCF/BO, 89 TCF of CO_2 would be needed



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Implementation: Option #1

CO_2 "huff-n-puff"

- Pros
  - Use existing wellbores
  - Exploitation of know flowpaths
  - Ability to use produced gas as well that may be currently flared
  - Existing EOR projects in Eagleford & Bakken show ~30%-50% type uplifts in EUR with natural gas (CO_2 should do better)
- Cons
  - Shut in oil production for the injection and soak period (up to 30 days)
  - Requires multiple cycles
  - Requires sizeable upfront CAPEX for compression

Implementation: Option #2

Dedicated CO_2 Injection

- Pros
  - Don't have to take producers offline
  - Mobilization of a larger area of oil-bearing rock
  - Ability to use produced gas as well that may be currently flared
- Cons
  - Requires sizeable upfront CAPEX to drill dedicated injectors (horizontal or vertical)
  - Requires sizeable upfront CAPEX for compression
  - Requires continuous, reliable CO_2 supply
  - Will sweep efficiency be detrimentally impacted by the fracture network created?

Horizontal San Andres CO_2 Potential

- Why isn't it already on-going?
- Several obstacles to implementation
  - Majority of current operators are small in size or private equity backed
  - Long-term vision to invest tens of millions of dollars in a long payout project
  - Optimistic forecast of long-term oil prices (can't hedge until the oil shows up)
  - Constrained CO_2 supply in the Permian
    - Natural supplies are primarily accounted for through long-term contracts
    - Anthropogenic capture needs to fill the gap (at an economic rate)

Summary

- Billions of barrels of recoverable oil lies in the San Andres formation of the Permian Basin
- The stranded oil can, and has been, recovered through CO_2 injection and gas can be sequestered
- The horizontal San Andres play has 500+ wellbores available for implementation close to existing CO_2 pipeline networks
- Several issues like CO_2 supply, capital allocation need to be resolved for the next phase of the play to get underway, ultimately oil price (or carbon credits) will be the catalyst.

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Questions?