CO₂ EOR Technology Note:
Evidence Supporting Supplemental Rock Diagenesis Making ROZs Different than Main Payzones

a Brief Report from the PB ROZ Group
Steve Melzer

Midland Center
December 7, 2012
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Understanding ROZs: Progress

1. On-going Research
2. Origins
3. Permian Basin Distributions
4. ROZ Properties
Understanding ROZ Response

ROZ Science

Permian Basin Regional

RPSEA I
May '09 - Apr '12

DOE NEXT GEN
Mar '11 - Mar '13

RPSEA II
May '11 - May '14

PRIVATE CLIENT
ROZ STUDIES

And Looking Outside the PB as Well

Melzer Consulting
ROZ Origins
Permian Basin and Wyoming (Big Horn) ROZ Studies

- Many Basins in the World Possess Multiple Stages of Tectonics
- If a Basin has a Post Oil Entrapment Stage, Water Can Encroach Upon an Oil Reservoir and Sweep the Mobile Oil Out
  - A Residual Oil Zone (ROZ) Will be left Behind (We Call these “Naturally Waterflooded” Reservoirs)
- If the Residual Oil Saturation Left Behind is Sufficient (>20-25%), EOR Processes Will Work There Just Like they Have Worked in Man’s Water Floods
- Some Basins Possess Huge Amounts of Oil in the ROZs
  - Permian Basin San Andres Appears to have in Excess of 100 billion barrels in Place in the ROZs
  - Big Horn Basin Also Has a Huge Target Resource of Oil in Place
ROZ Type III Animation
(First Draft)
The Permian Basin

Our Latest ROZ Distribution Map
ROZ Properties
Diagenetic Changes in the ROZ

Biogenic Chemical Reaction

\[ \text{CaSO}_4 + \text{HC} \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} + \text{S} \]

Abiotic Chemical Reactions

\[ \text{CaCO}_3 + \text{Mg} \rightarrow \text{MgCa(CO}_3\text{)}_2 \]

Picked up as Flush Water Moves through Mg Salts?
Is this (Pervasive) Dolomitization Process Important?
Technical Evaluation – Petrophysics

From Thurman, Legado Resources, CO₂ Flooding Conference, Dec 2010
Yet Another Well Log
Midland Basin San Andres Shelf
Porosity and PhotoElectric Crossection Logs

PhotoElectric Crossectional Value of 3: = Dolomite
(Anhydrite and Calcite = 5+)

Melzer CO₂nsulting
Conclusions

• ROZ Origins in the Permian Basin are Mother Nature’s Waterfloods and are Predominately Type III – laterally flushed.

• Anaerobic Processes are Responsible for the Sulfur Release (H₂S), Souring of the Oil and Gas, and Alteration of Disseminated Anhydrite to Calcite.

• Flushing Processes Convert the Calcite to Dolomite.

• Results are a late stage, Pervasive Dolomitization with Enhanced Porosities & Permeabilities.

• Evidence Includes Log Character and Anomalously Uniform PE Log Values of 3.