Lower Cretaceous Pearsall Oceanic Anoxic Events and Associated Development of Shale-Gas Reservoirs in South Texas*

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Abstract

The Lower Cretaceous Pearsall Formation in South Texas contains three calcareous, terrigenous mudstone intervals that are productive shale-gas reservoirs or that have the potential to be shale-gas reservoirs. The intervals are the Pine Island Shale, Lower Bexar Shale, and Upper Bexar Shale members. Each member is associated with the OAE-1 time interval, during which the Pearsall distal steepened ramp was transgressed and flooded. The Pine Island Shale Member contains the OAE-1A, the Lower Bexar Shale Member contains a regional OAE, and the Upper Bexar Shale Member contains OAE-1B. Secular carbon isotope curves record these OAEs and allow their correlation, not only within the GOM, but also worldwide. In the outer-ramp setting during OAEs, sedimentation was dominated by calcareous siliceous mudstone and argillaceous lime wackestone. Dysoxic to anoxic bottom conditions existed, favoring the preservation of organic matter. TOC content increases in the offshore direction, reaching up to an average value of 1.8% (high single value of 2.8%) near the paleo-Sligo shelf edge. The reservoir may be composed of a dual pore network of open-mode, tectonic-related fractures and matrix interparticle and intraparticle nano- to micropores. Matrix porosity ranges between 4 and 8%, and matrix permeability ranges between 4 and 70 nd. The Pearsall outer-ramp facies belt throughout the GOM is expected to have environmental conditions similar to those in South Texas and therefore is expected to be a prospective shale-gas system. The limiting factor will be depth of burial and associated economics.

Selected References

Hull, P.M., and R.D. Norris, 2011, Diverse patterns of ocean export productivity change across the Cretaceous-Paleogene boundary: New insights from biogenic barium: Paleoceanography, v. 26, 10 p.

Hull, J.T., 2008, Depositional history, sequence stratigraphic framework, and reservoir characterization of the Lower Boatwright sequence (Lower Springer trend) in Verden Field, Oklahoma: M.S. Thesis, University of Oklahoma, Norman, Oklahoma, 133 p.

Jones, C.E., and H.C. Jenkyns, 2001, Seawater strontium isotopes, oceanic anoxic events, and seafloor hydrothermal activity in the Jurassic and Cretaceous: American Journal of Science, v. 301/2, p. 112-149.

Kump, L.R., and M.A. Arthur, 1999, Interpreting carbon-isotope excusions: carbonates and organic matter, *in* J. Veizer, (ed.), Earth system evolution; geochemical perspective: Chemical Geology, v. 161/1-3, p. 181-198.

Phelps, R.M., 2011, Middle-Hauterivian to Lower-Campanian sequence stratigraphy and stable isotope geochemistry of the Comanche platform, south Texas: Ph.D, University of Texas at Austin, Austin, Texas, 227 p.

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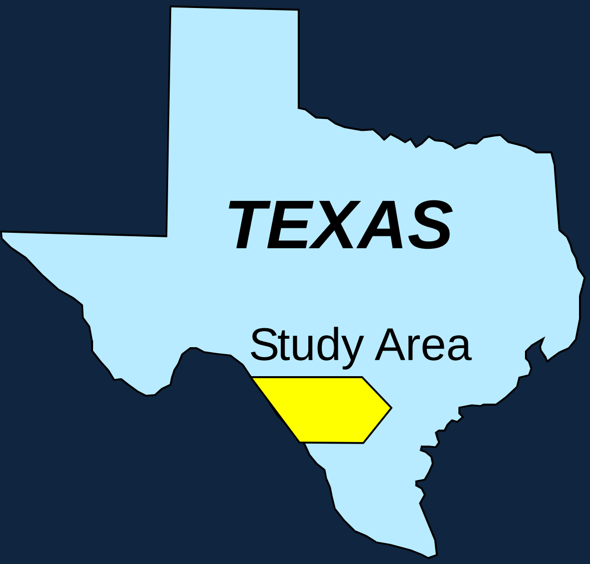
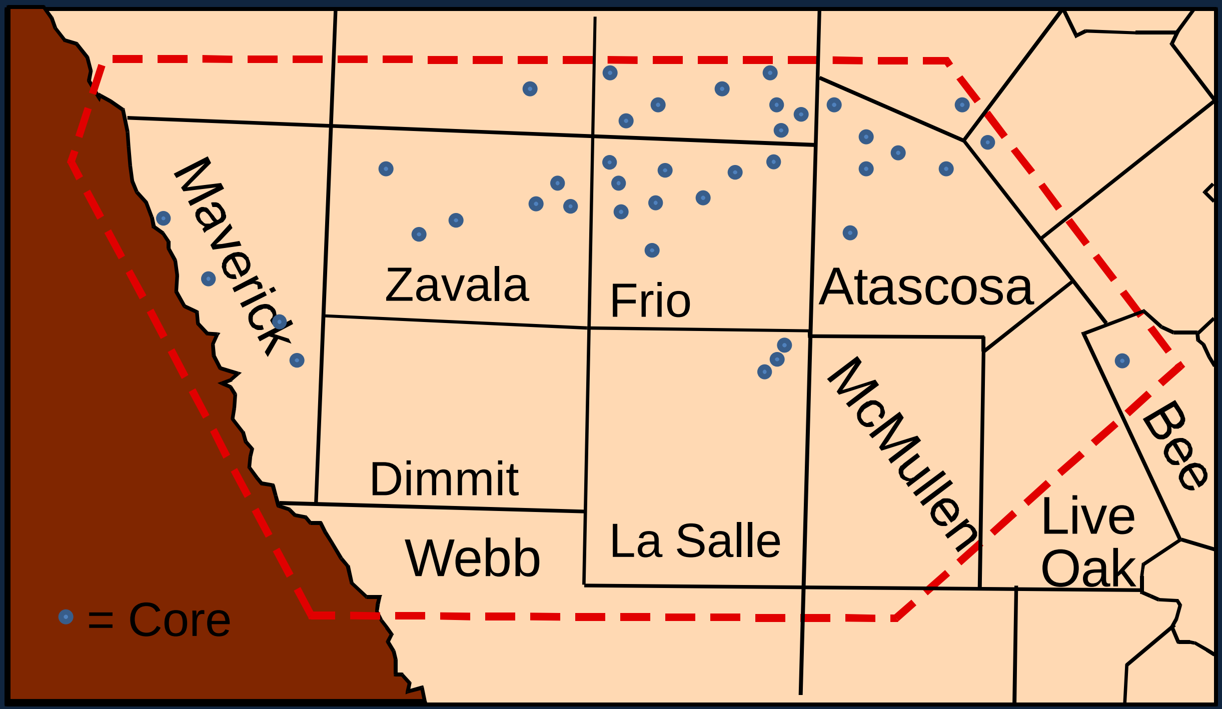
Introduction

- The Pearsall Formation was a mixed system deposited during the Aptian age of the Cretaceous
- Paleogeography, sea-level changes, and environmental events (Oceanic Anoxic Events, OAE’s) played a role in its deposition
- The Pearsall Shale has the TOC and porosity necessary to be a shale-gas system

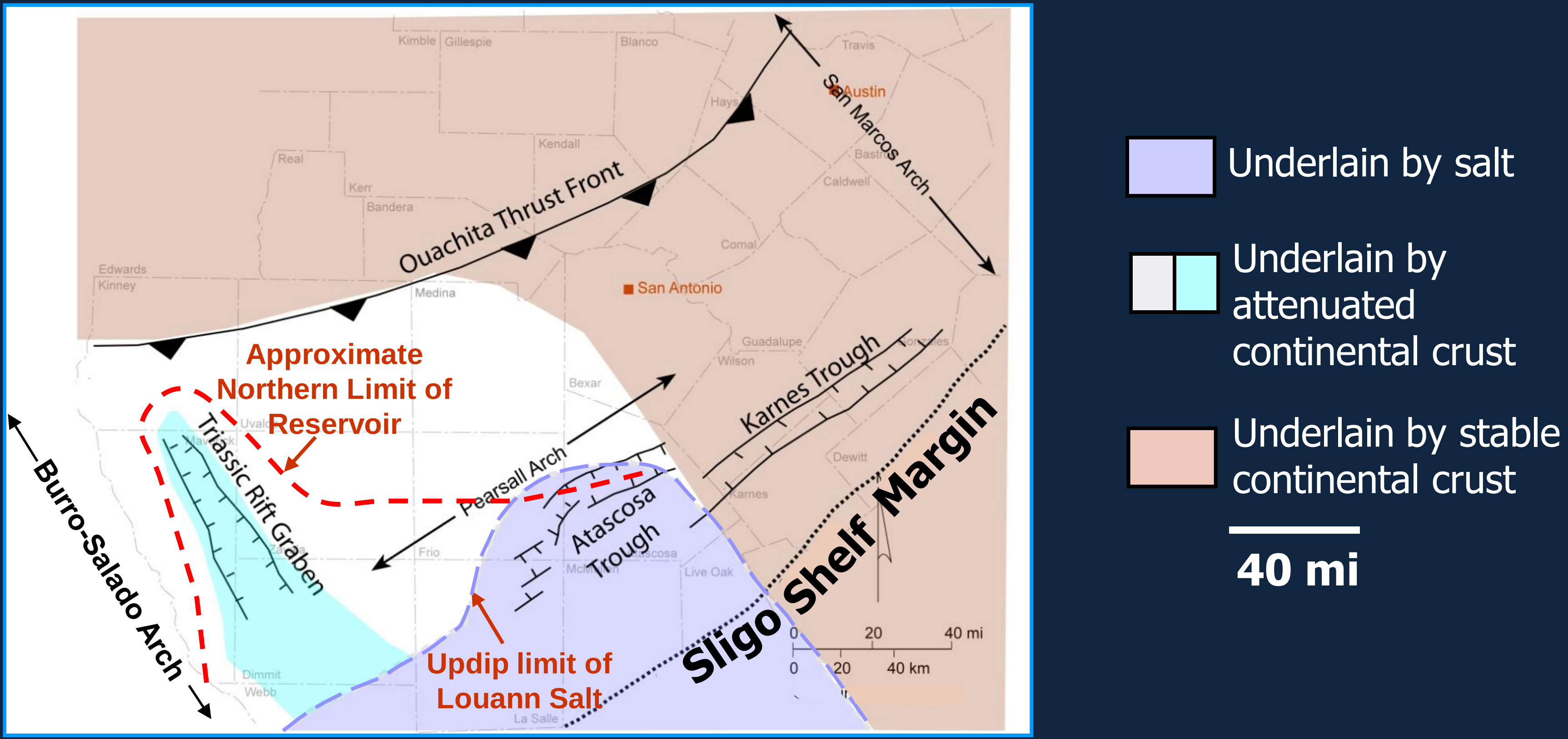
Study Area and Data

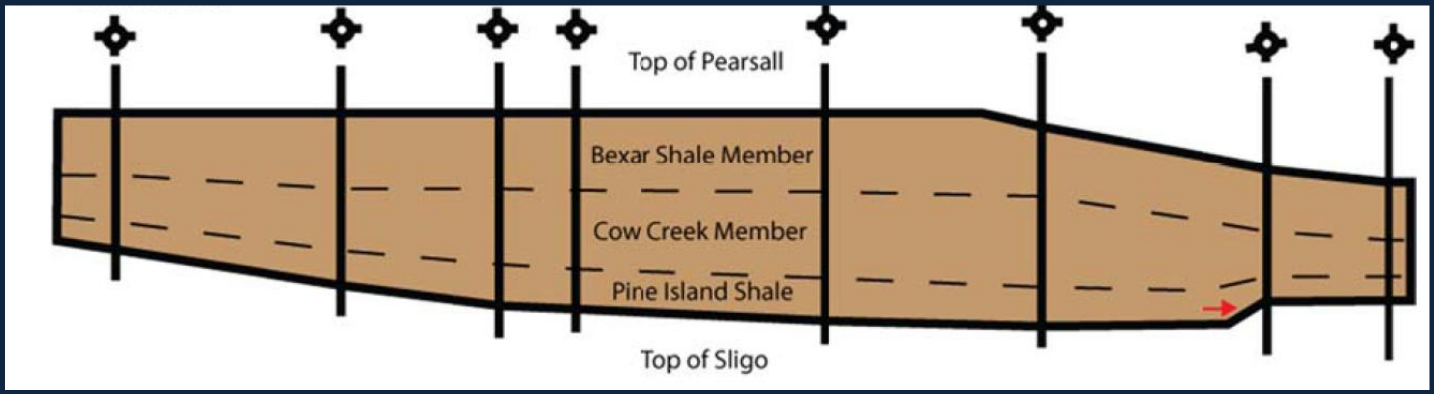
- ~185 well logs (SP and resistivity)
- 44 cores (mostly in the updip area)
- Carbon isotope profiles
  and other geochemical data



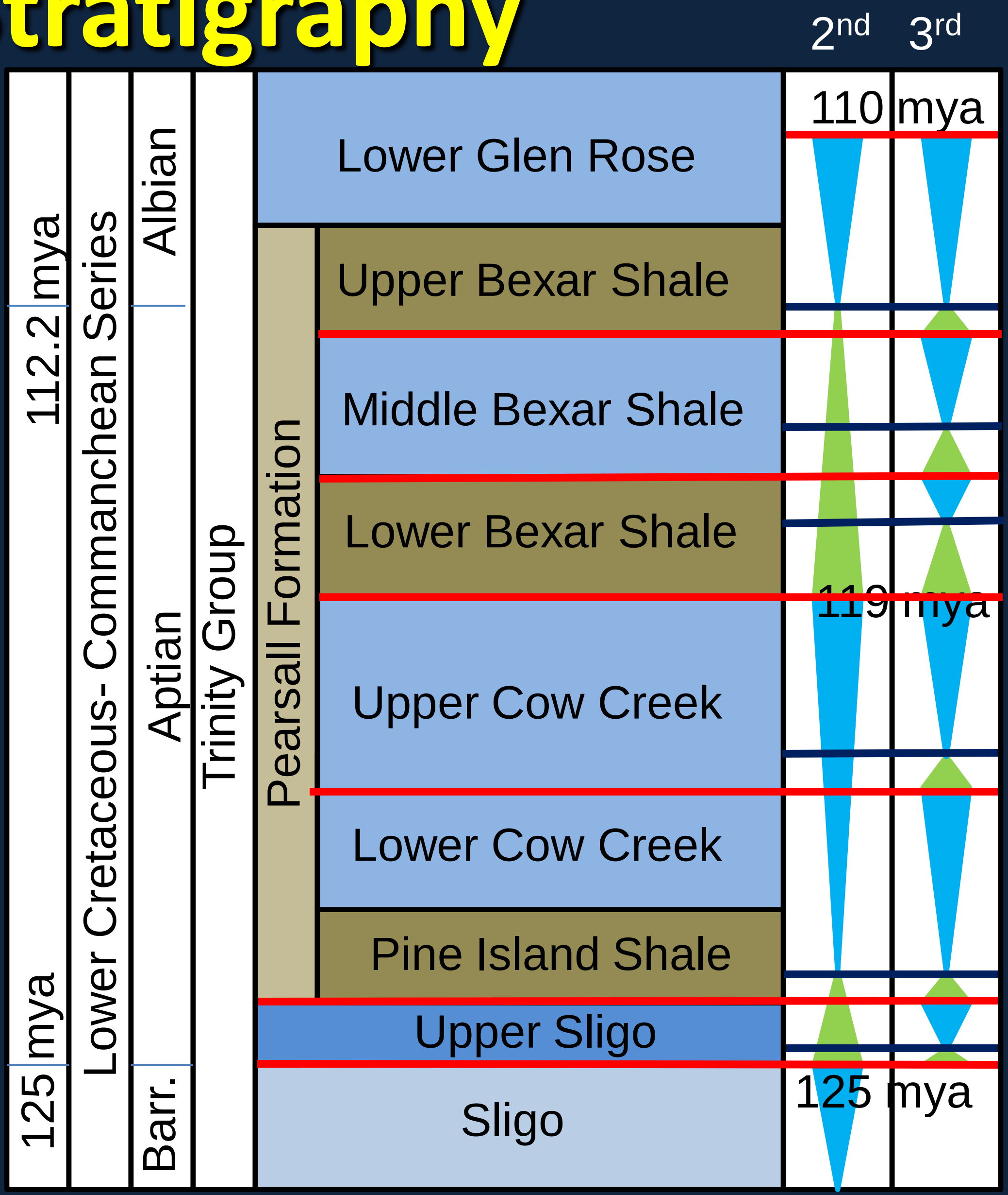


Paleogeography





Lithostratigraphy to Sequence Stratigraphy

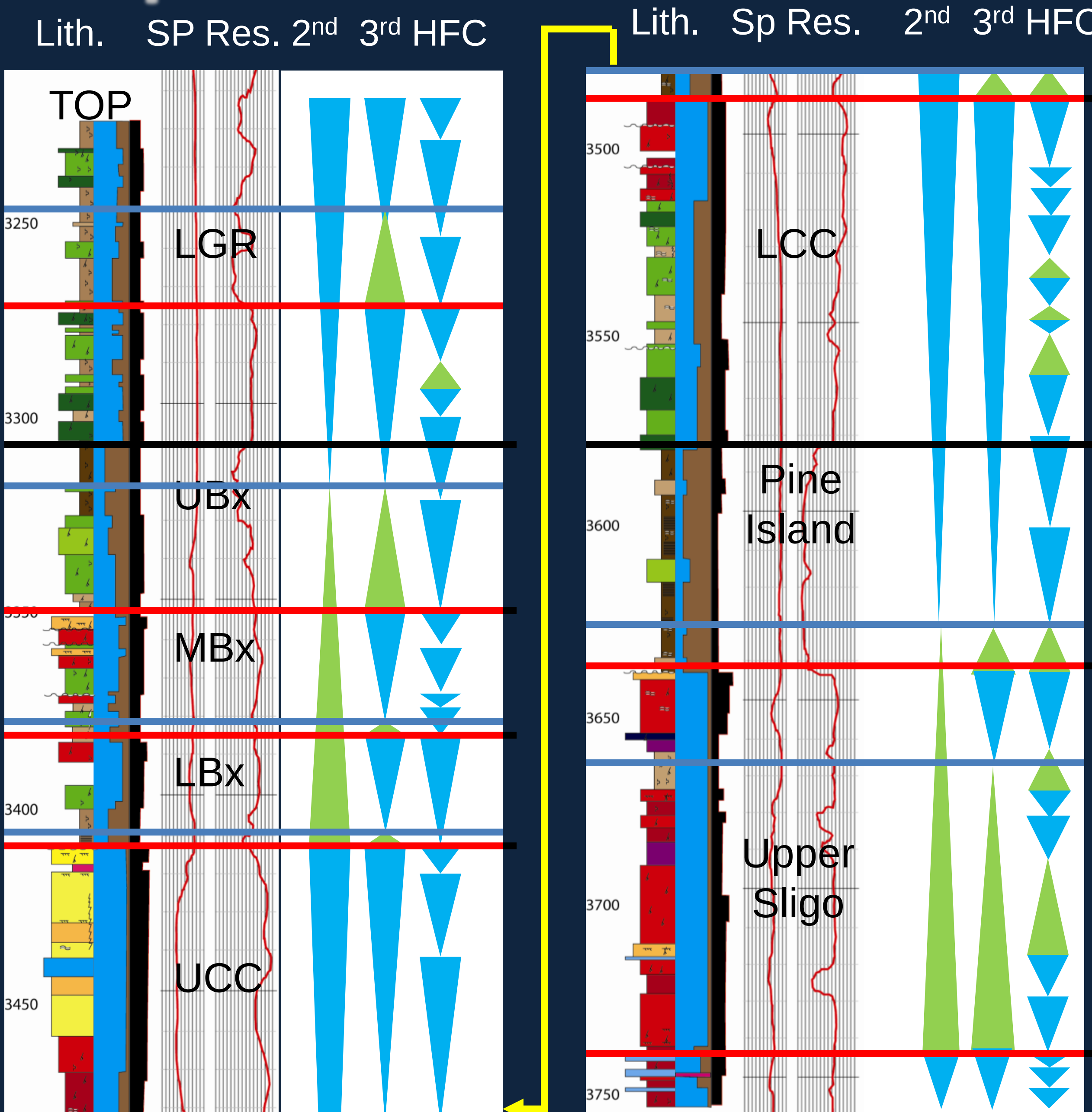


- Due to depositional setting on a distally steepened ramp, lithostratigraphy reflects sequence stratigraphy
- 5 third-order cycles were identified to be correlative basin-wide.

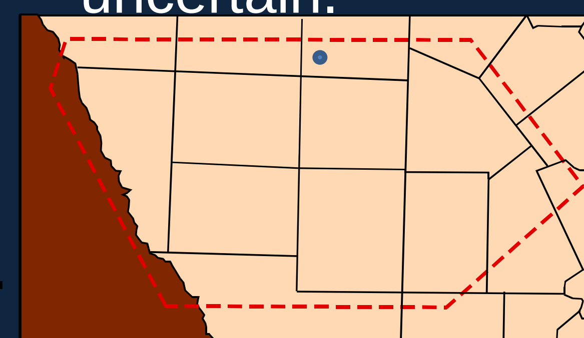
= MFS = Sequence Boundary

(2^{nd} order interpretation by Phelps, in press)

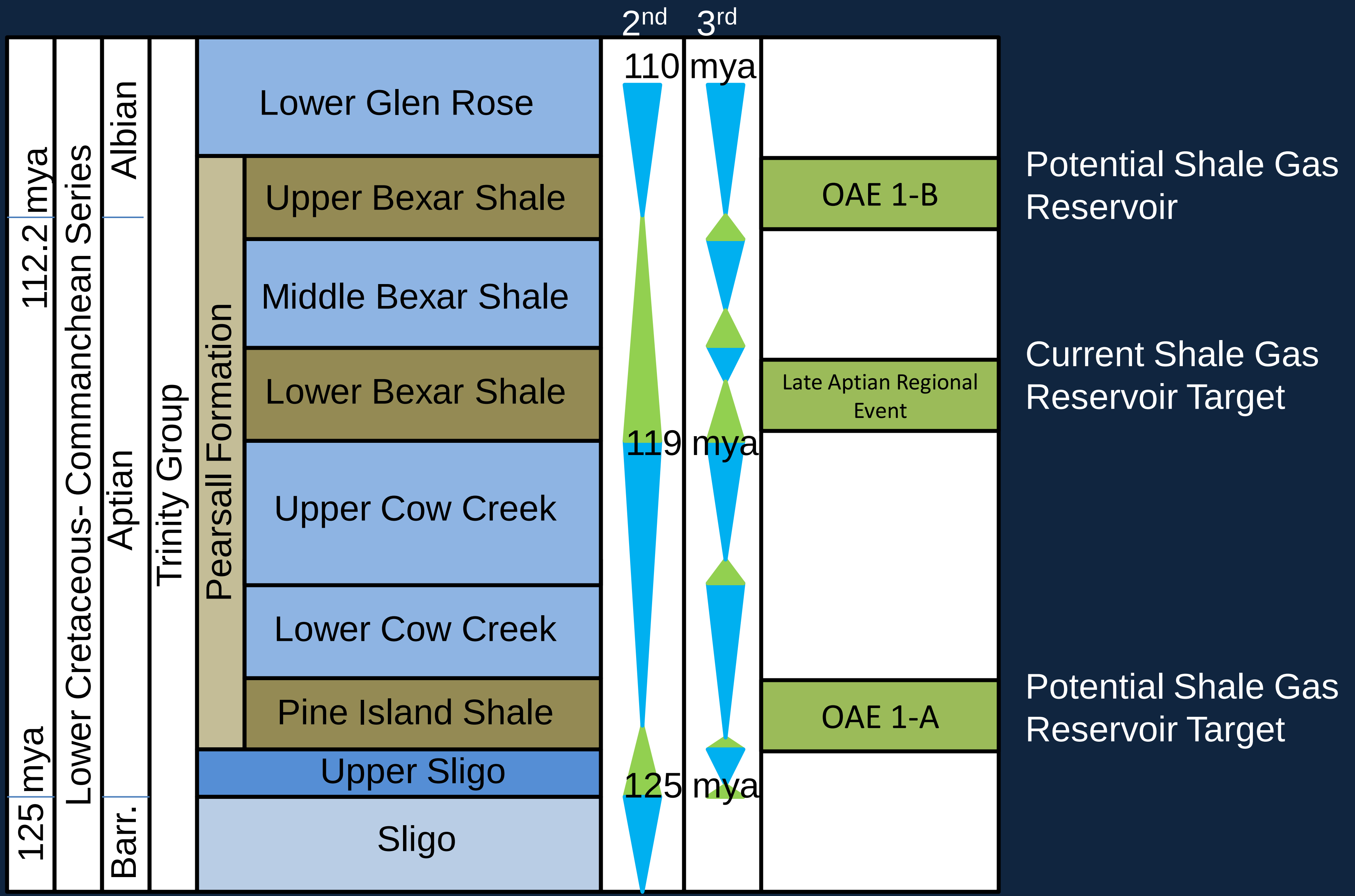
Sequences in the Tenneco #1 Ney



- Complete Pearsall cored section from Sligo to the Lower Glen Rose.
- Five 3rd order cycles identified in the Pearsall.
- Numerous HFC seen but time scales and correlatability are uncertain.



Pearsall Formation Stratigraphic Section, OAE's and Potential Productive Zones

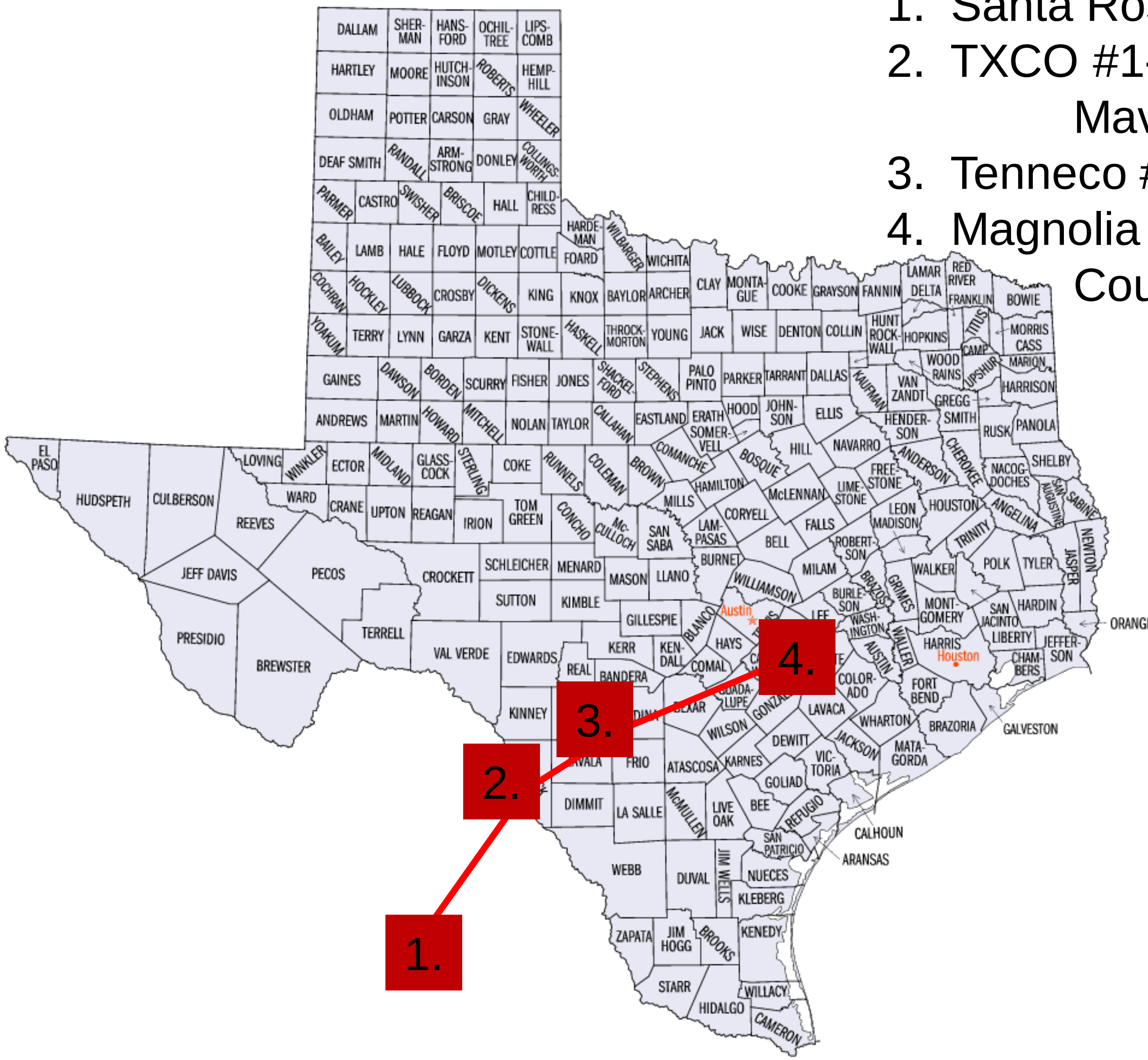


The Carbon Isotope Record and OAEs

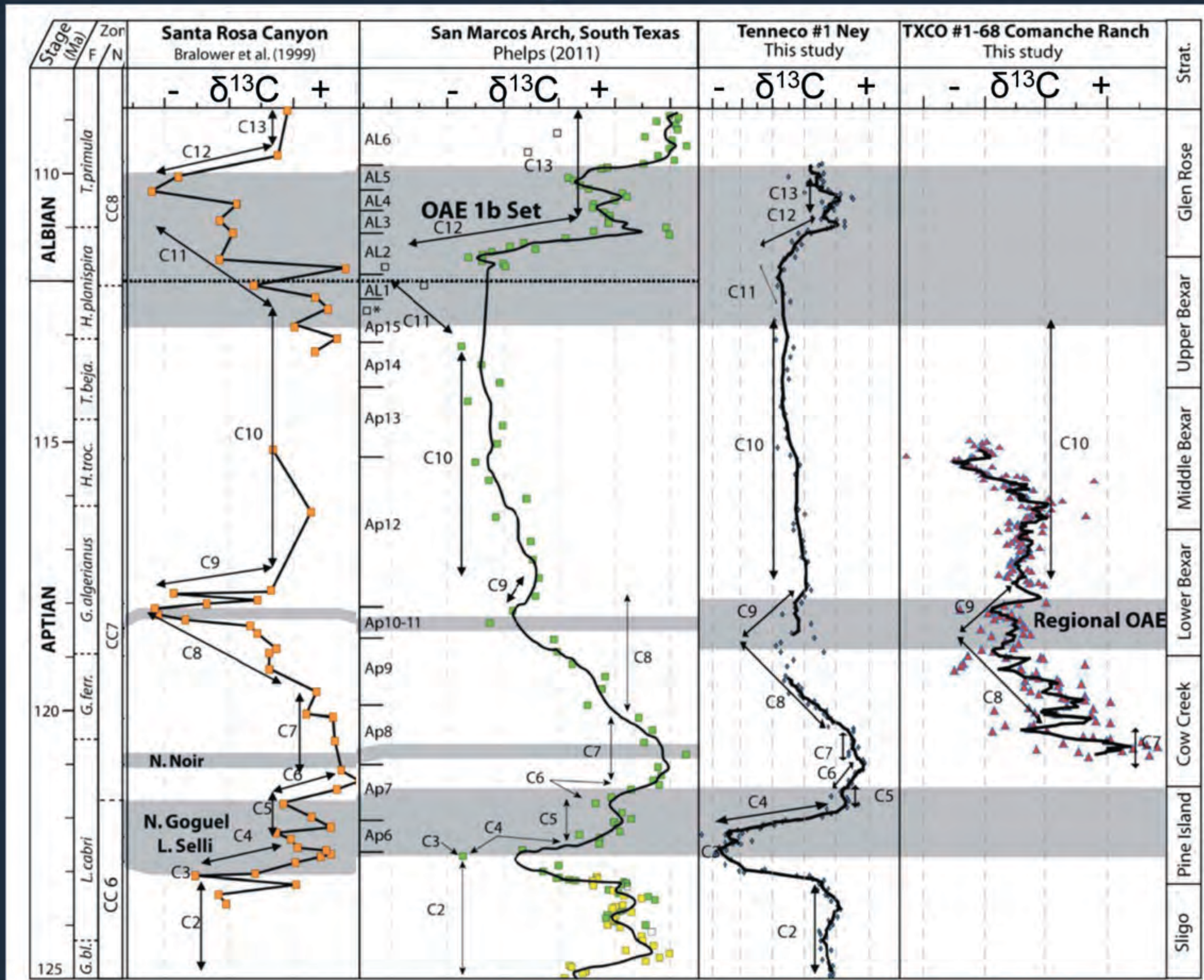
- Carbon isotope curves are thought to reflect changes in global carbon cycling (Kump and Arthur, 1999).
- Decreases in the $\delta^{13}C$ ratio indicate the input of isotopically light carbon through a variety of processes, including volcanic and hydrothermal activity associated with increased seafloor spreading (Jones and Jenkyns, 2001).
- Increases the $\delta^{13}C$ ratio indicate removal of light ^{12}C from the system through the sequestration of organic matter. This process is TOC preservation (Jones and Jenkyns, 2001).

δ^{13}C Correlations Across the Shelf

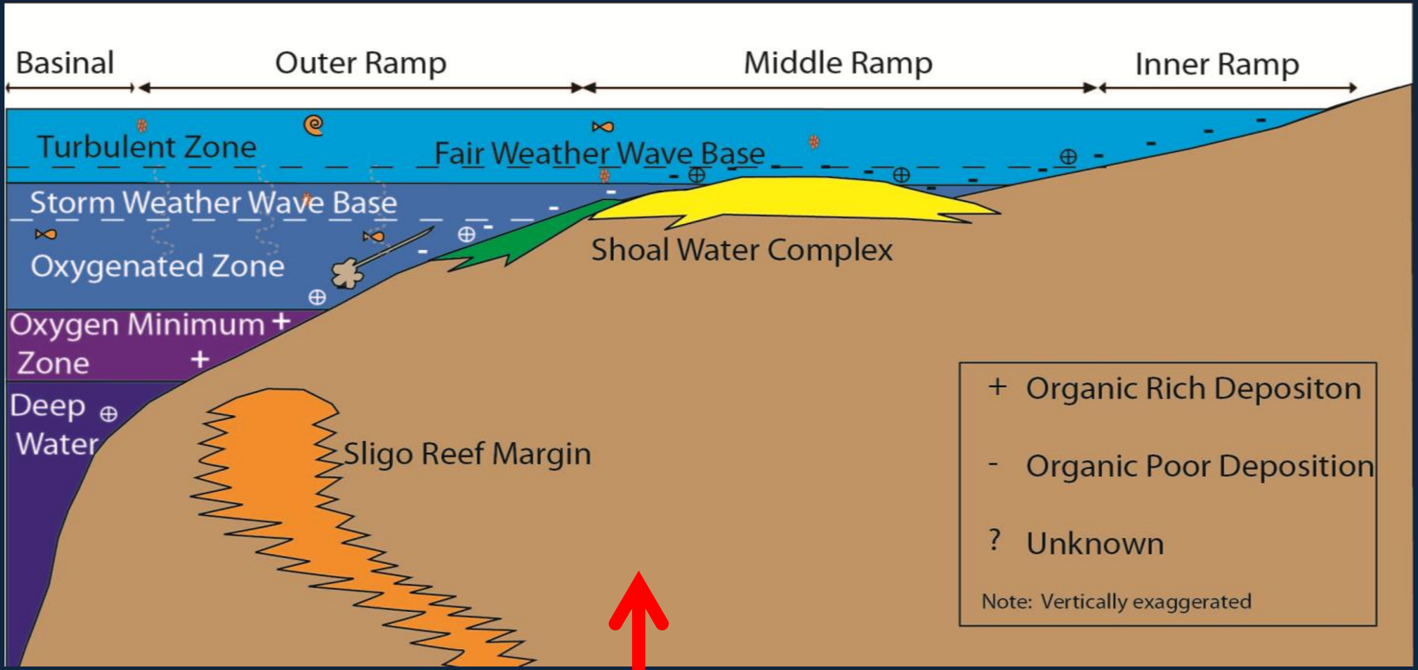
1. Santa Rosa Canyon, Mexico
2. TXCO #1-68 Comanche Ranch, Maverick County
3. Tenneco #1 Ney, Frio County
4. Magnolia #1 Mercer, Caldwell County



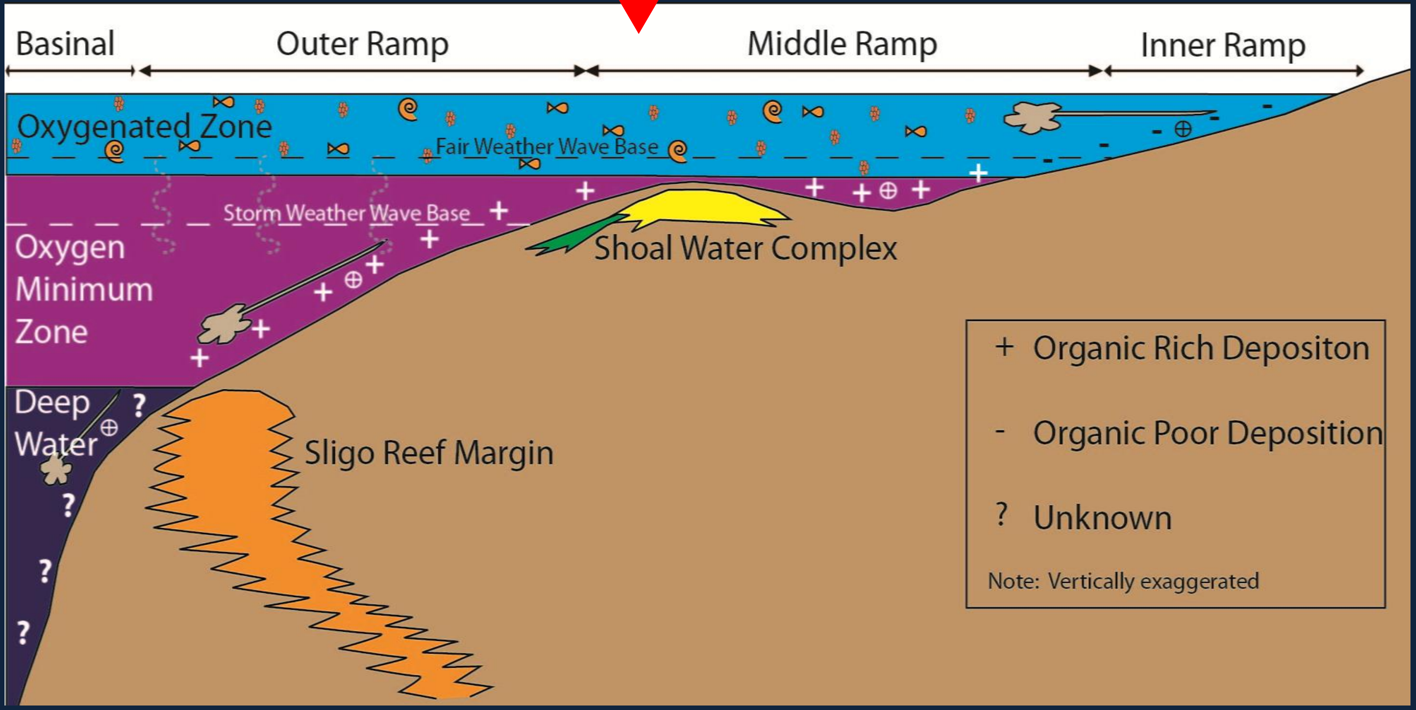
The Carbon Isotope Record



(Modified from Phelps 2011 and Hull 2011)

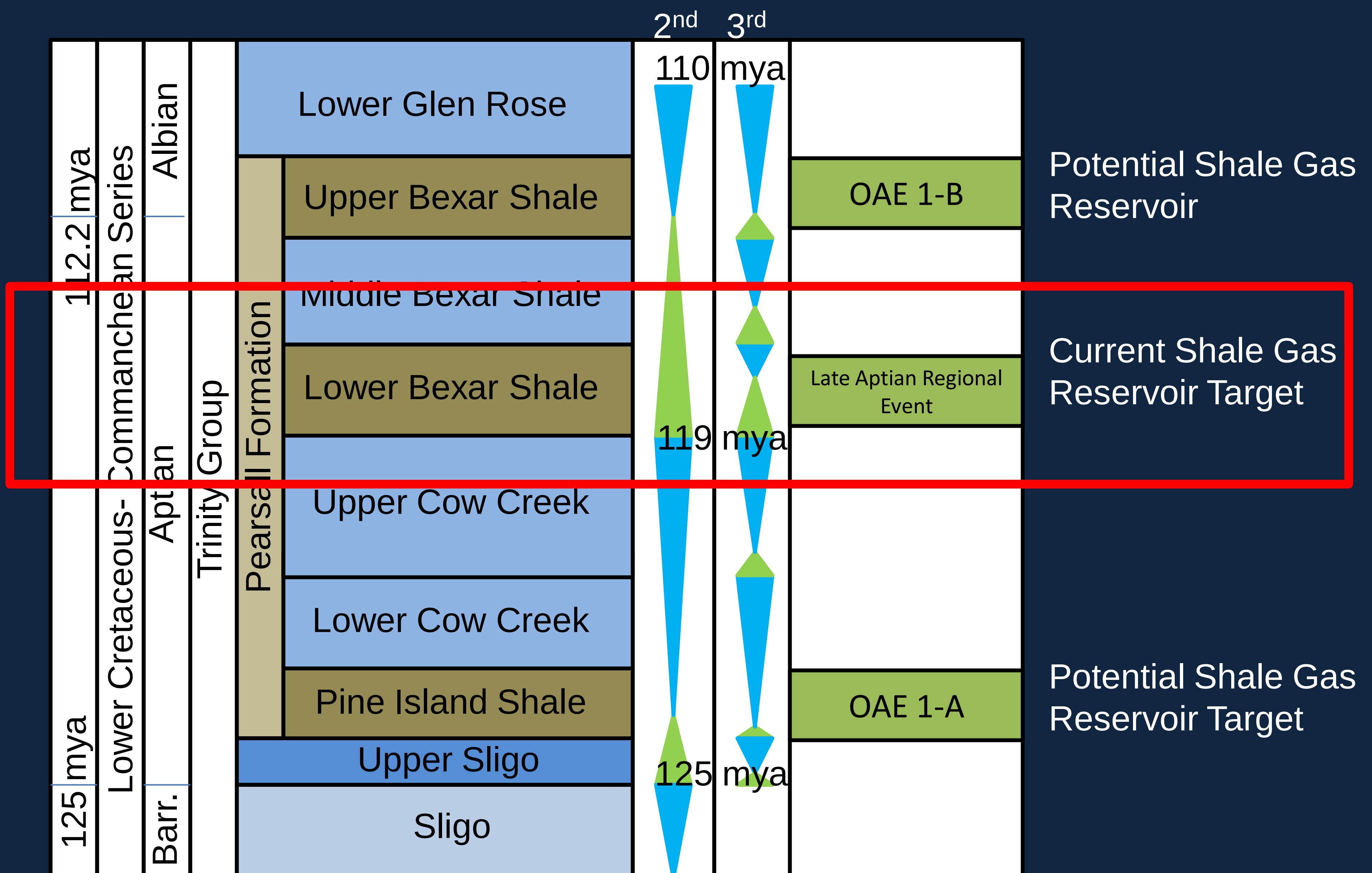


Normal depositional environment



OAE driven depositional environment

Lower Bexar Reservoir



Lower Bexar Reservoir Facies

Weakly laminated to massive calcite silt-bearing terrigenous mudstone

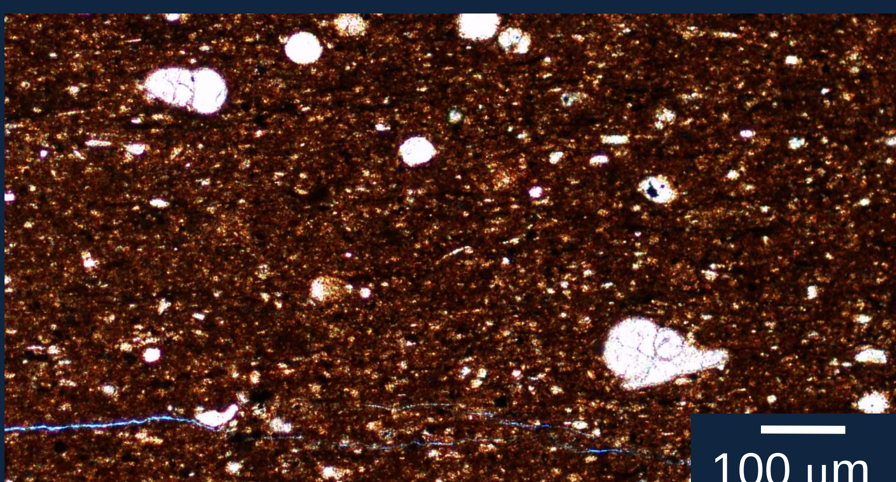
Tidewater 2 Wilson 11,845’

1 inch

Winnowed non-bioturbated calcite silt-bearing terrigenous mudstone

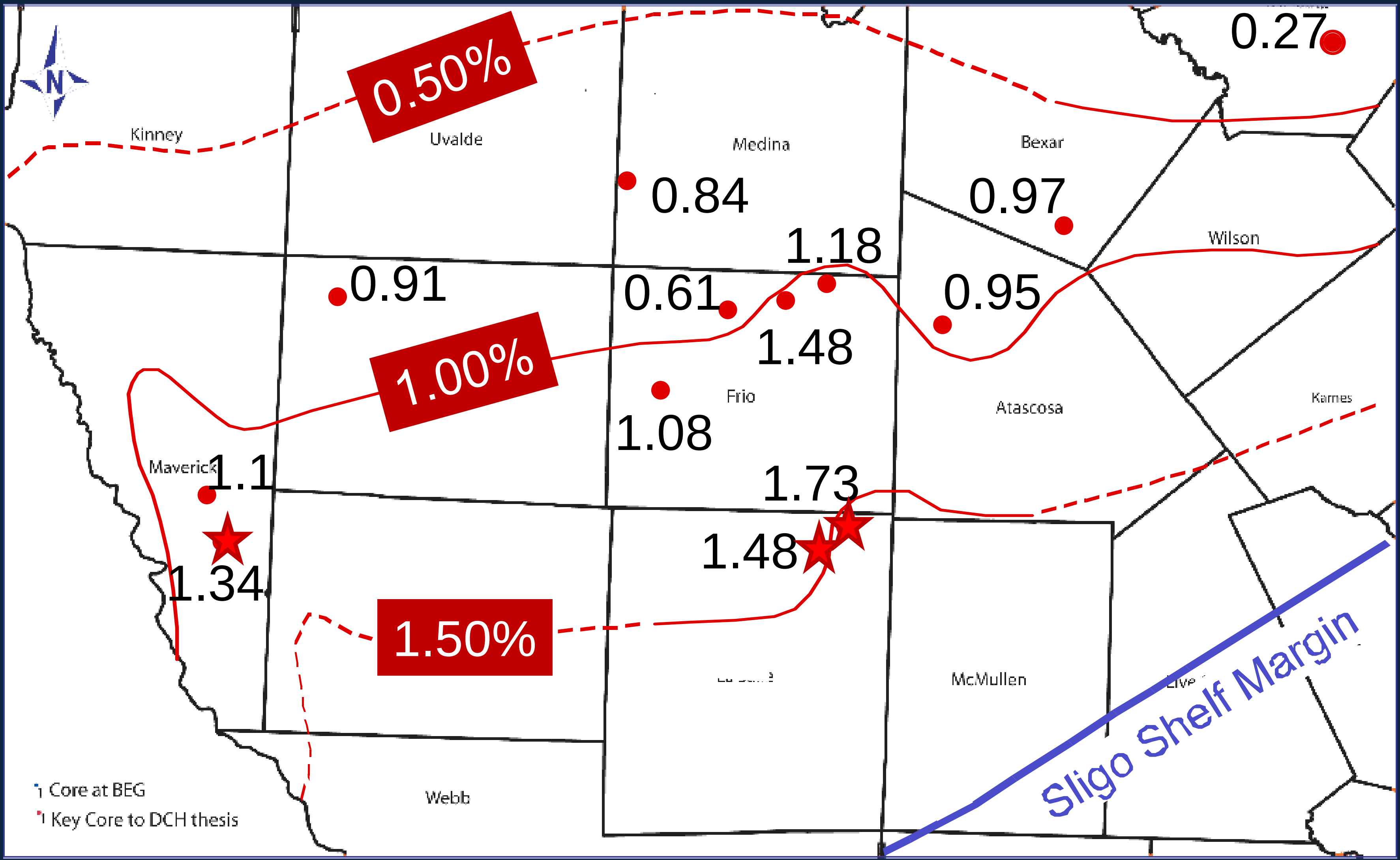
TXCO Comanche Ranch 8449.5’

1 inch

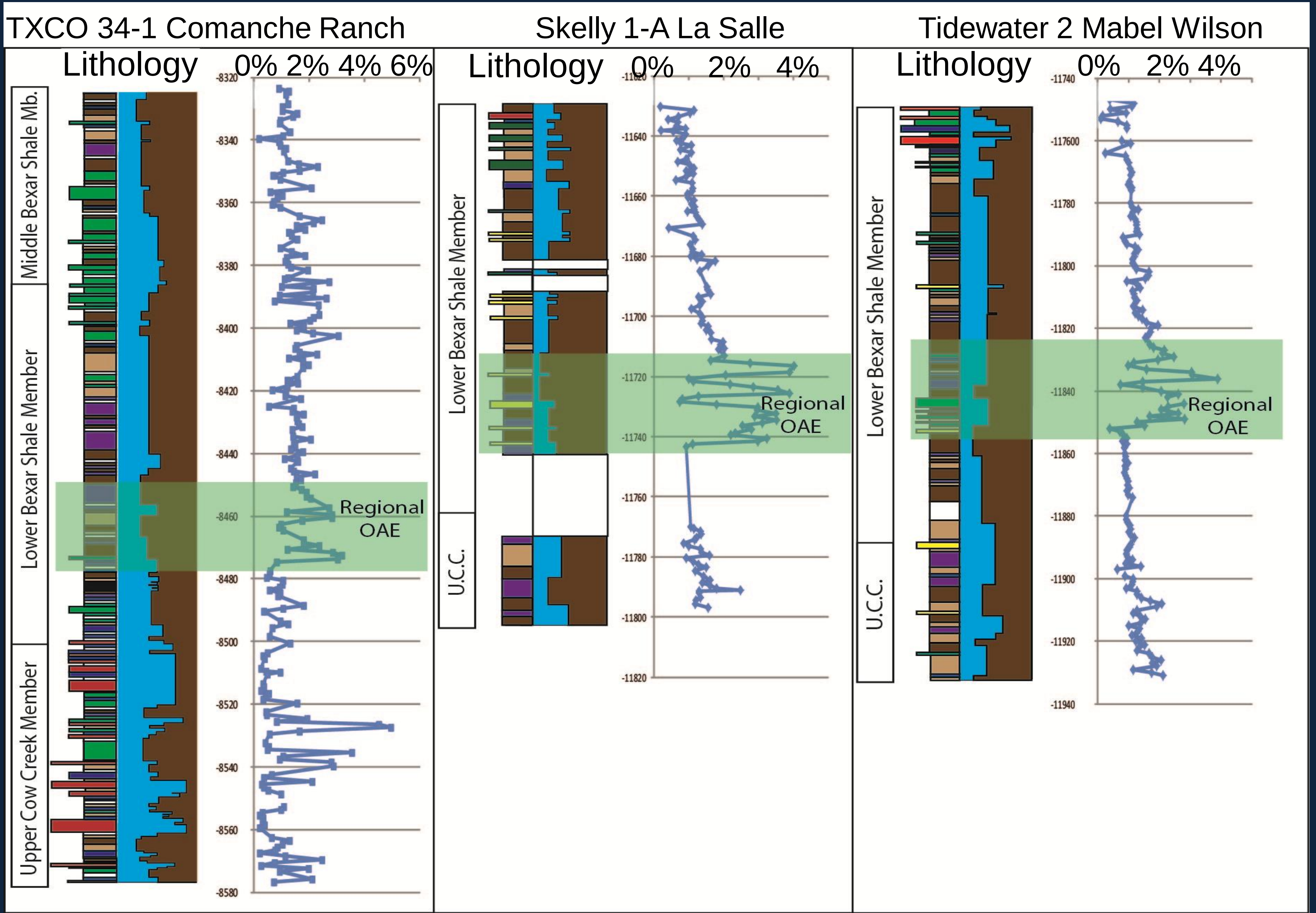


Tidewater #2 Wilson 11,813’

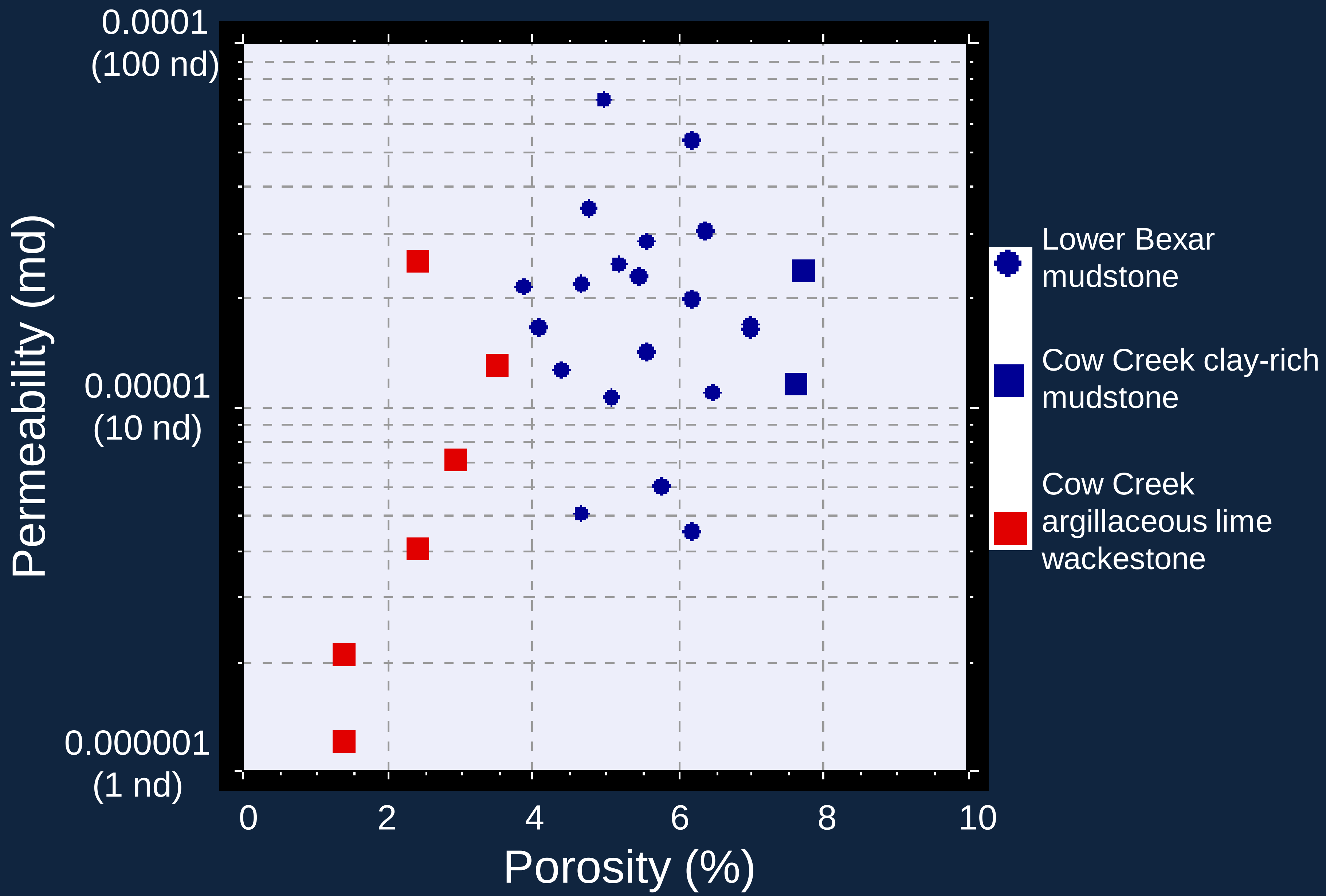
Lower Bexar TOC



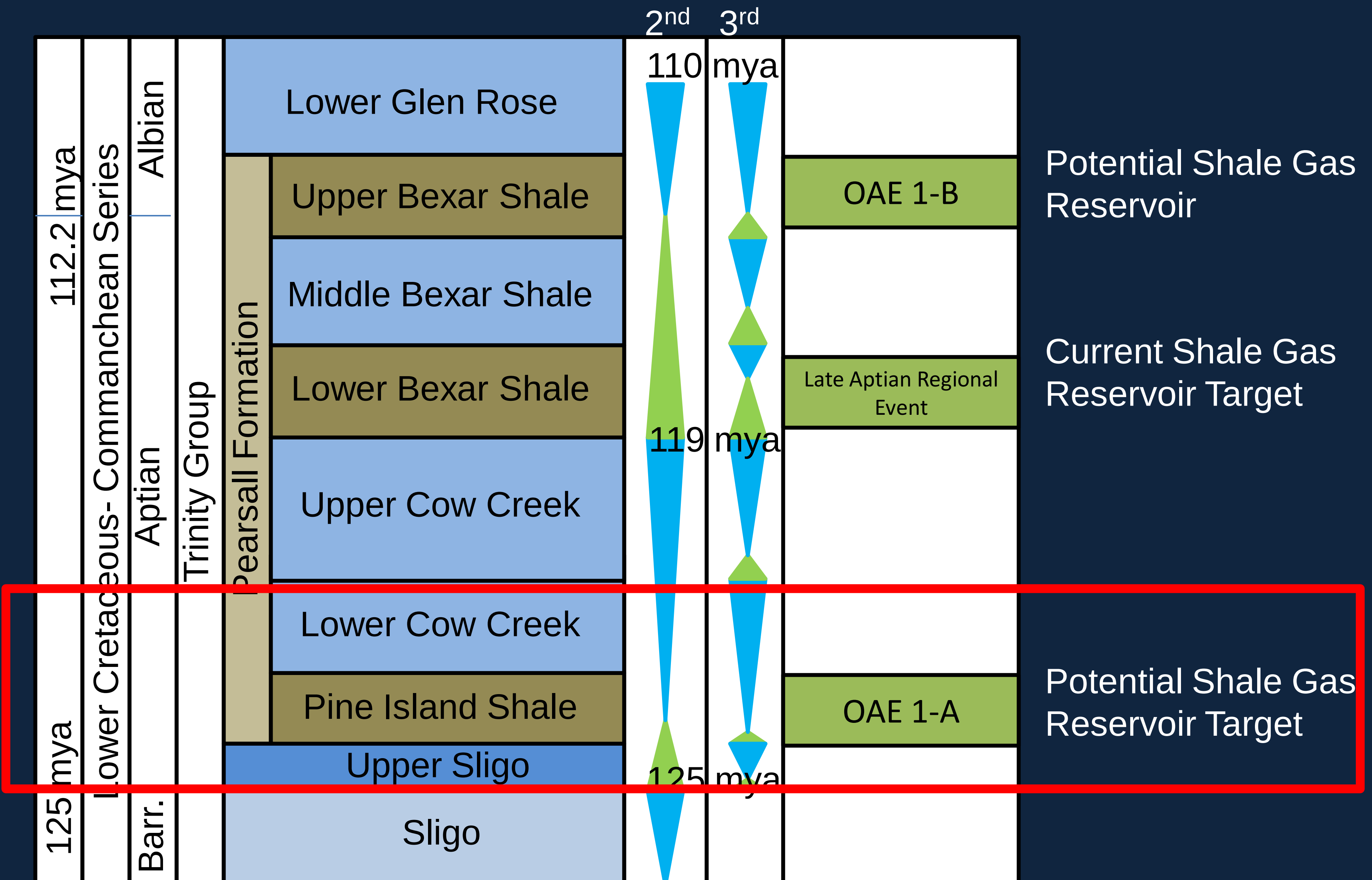
Lower Bexar TOC



Lower Bexar: Porosity and Permeability

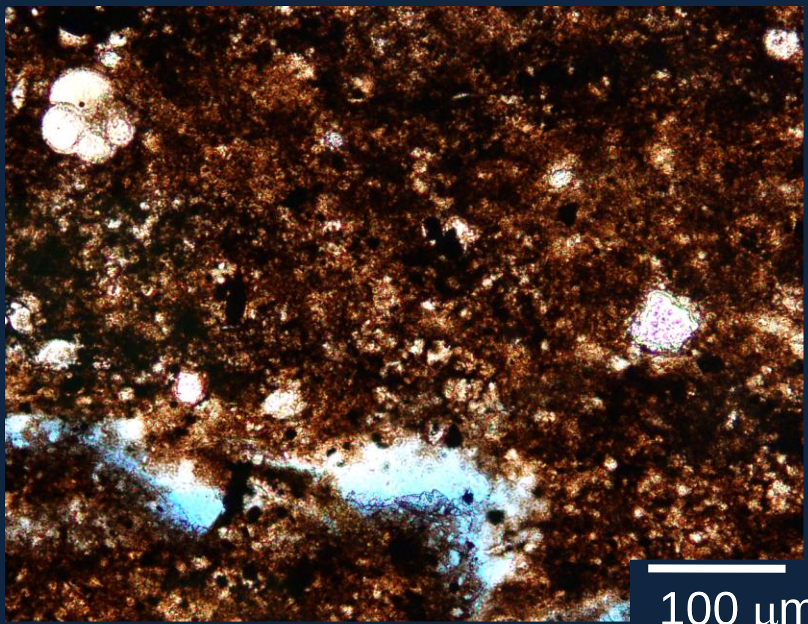


Pine Island Reservoir



Pine Island Reservoir Facies

Peloidal terrigenous mudstone

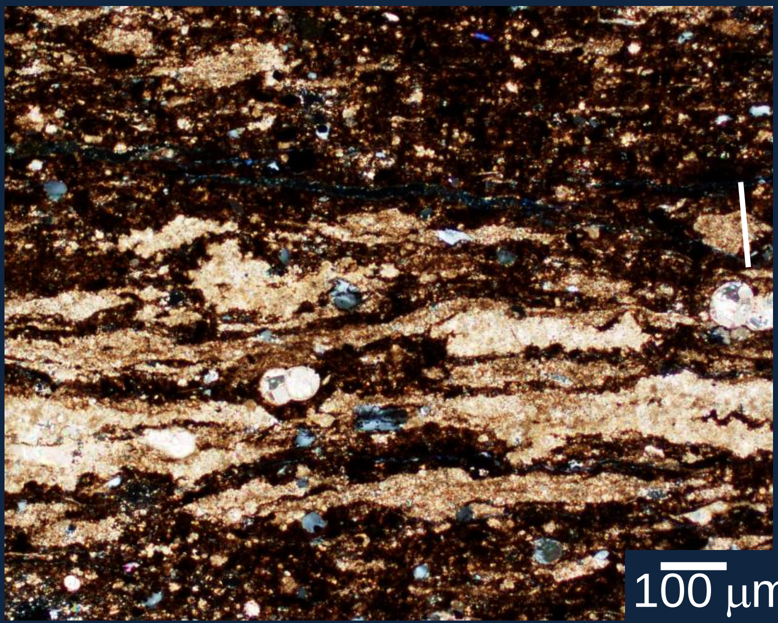


100 μm

Shell #1-R Roessler 15,925’

1 inch

Peloidal calcareous terrigenous mudstone



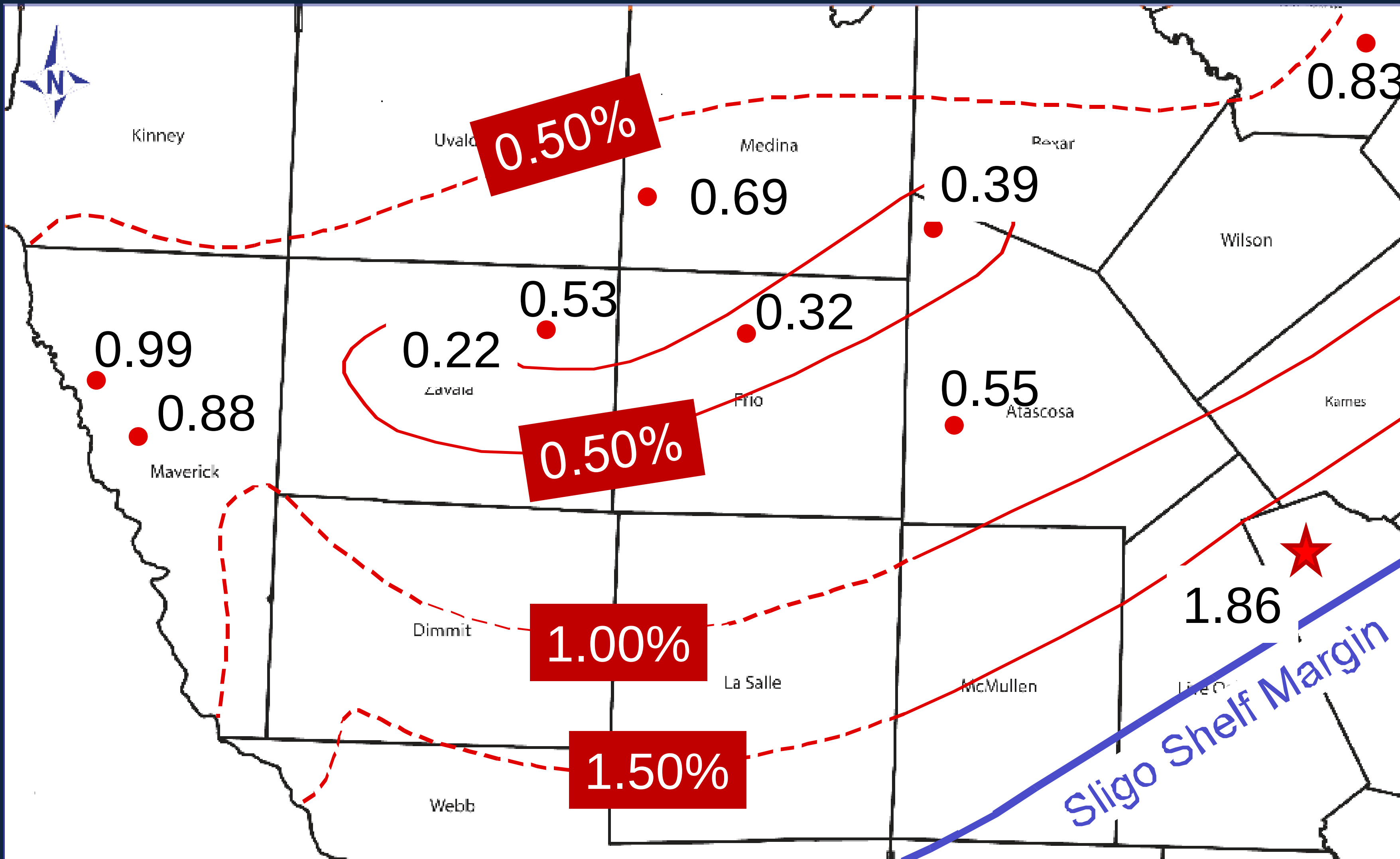
100 μm

Shell #1-R Roessler 15952.4’

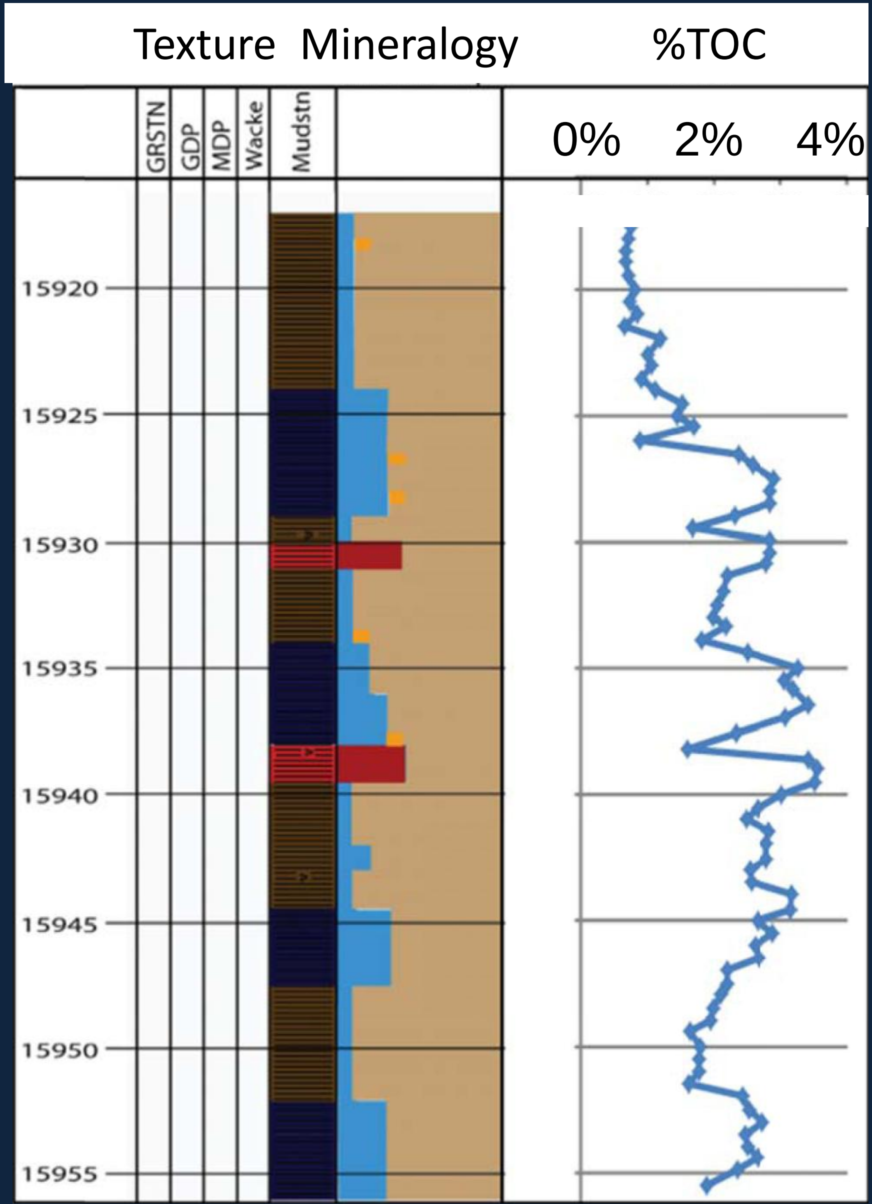
Shell #1-R Roessler 15926.5’

1 inch

Pine Island TOC

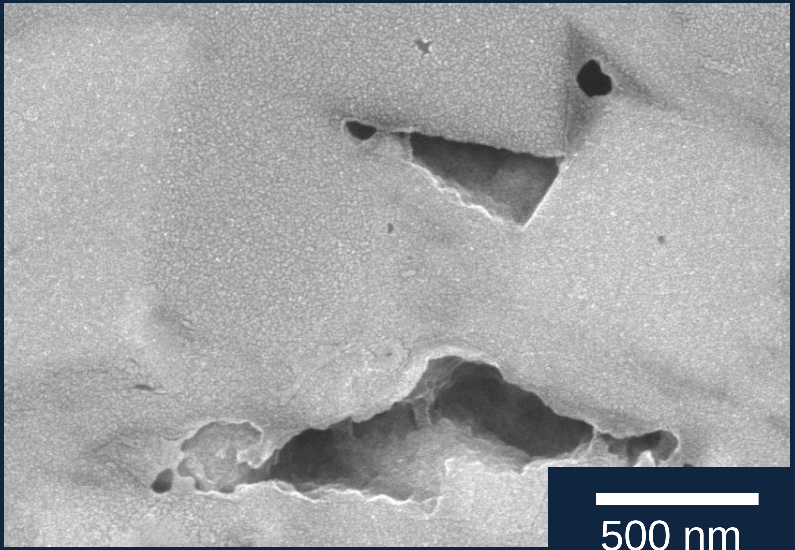


Pine Island TOC and Pores



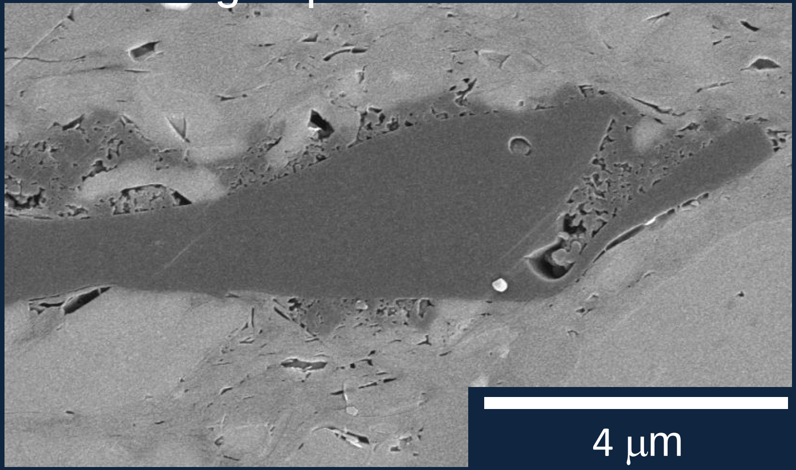
Shell #1-R Roessler

Interparticle pores



Humble #47 Pruitt 9,700'

Intra-kerogen pores



Shell #1-R Roessler 15934'

Conclusions

- Paleogeography, sea-level changes, and environmental changes contributed to the development of a favorable depositional environment for shale gas during the Pearsall
- The Pine Island Shale Member and Lower Bexar Shale Member both contain porosity and organic-rich source rock
- These members and the Upper Bexar Shale member, deposited under a similar depositional regime, warrant further consideration as shale gas targets when economics can be improved

Questions and Acknowledgements

- Bob Loucks and Kitty Milliken
- Ryan Phelps and Ryan Harbor
- Harry Rowe
- The Jackson School at the University of Texas
- Et al.