New Model for Halokinetically Controlled Patch Reef Systems: A Case Study From the Fairway Field, A Major Aptian Reservoir in the East Texas Basin*

Kelly E. Hattori[1], Robert G. Loucks[1], and Charles Kerans[2]

Search and Discovery Article #11250 (2019)**
Posted September 9, 2019

*Adapted from oral presentation given at 2019 AAPG Annual Convention and Exhibition, San Antonio, Texas, May 19-22, 2019
 DOI:10.1306/11250Hattori2019

[1]Bureau of Economic Geology, The University of Texas at Austin, Austin, TX (kelly_hattori@utexas.edu)
[2]The University of Texas at Austin, Austin, TX

Abstract

The Fairway Field is a major (410 MMbbl) Aptian reservoir in the East Texas Basin that produces from a James Limestone reef complex. It contains a complex mosaic of reefs, reef-derived grainstones, shallow subtidal packstones/wackestones, and oyster/rudist biostromes. Facies prediction is limited because of significant lateral and vertical heterogeneity characteristic of reef systems. Previous attempts at characterizations of the Fairway Field have not fully considered the effect of eustatic fluctuations, antecedent topography, concurrent halokinesis, and resultant changes in depositional environment. This work assesses facies progressions from a sequence stratigraphic perspective, placing emphasis on syndepositional halokinetic movements in modifying the generalized south-facing shelf model. Reconstructing step-by-step depositional history improves predictive frameworks for reservoir facies in the Fairway Field and other analogous halokinetically controlled reef systems (GOM, UAE, Iran) by providing context for lateral and vertical facies heterogeneity. Isopach maps of the Pearsall Formation reveal antecedent topography present at the onset of the James Limestone that filled by end of carbonate deposition. Strata thicken to the NW for all members of the Pearsall Formation, reflecting the development of a salt withdrawal basin associated with the breached La Rue diapir. Strata thin to the SW, SE, and NE in the Pine Island Shale and James Limestone. The Fairway Field is centered over what was likely a NW-facing U-shaped embayment on the margin of a topographic high generated by uplift of the Brooks, Brushy Creek, and Boggy Creek salt pillows. Patch reefs initially grew within the embayment and around its margin, achieving greater vertical accretion on the edge adjacent to the basin and producing a system similar to that observed in modern atolls. During highstand, reefs contacted wave base and were eroded, filling the embayment with sediments that are now the primary reservoir facies. Salt pillow migration may have also contributed to reduction in accommodation. Later transgression resulted in deposition of low-energy, shallow shelf wackestones with chondrodont and rudist biostromes. In addition to highlighting the importance of antecedent topography and development of sequence stratigraphic frameworks, the Fairway Field patch-reef complex is an excellent case study for understanding heterogeneity in a halokinetically controlled localized shoaling area on a broad shelf.

References Cited

Bosence, D., 2005, A Genetic Classification of Carbonate Platforms Based on their Basinal and Tectonic Settings in the Cenozoic: Sedimentary Geology, v. 175, p. 49-72. doi:10.1016/j.sedgeo.2004.12.030

Ewing, T.E., 2016, Texas Through Time: Lonestar Geology, Landscapes, and Resources: Bureau of Economic Geology, The University of Texas at Austin, 431 p.

Giles, K.A., D.C. Druke, D.W. Mercer, and L. Hunnicutt-Mack, 2008, Controls on Upper Cretaceous (Maastrichtian) Heterozoan Carbonate Platforms Developed on Salt Diapirs, La Popa Basin, NE Mexico, *in* J. Lukasik and J.A.T. Simo (eds.), Controls on Carbonate Platform and Reef Development: Society for Sedimentary Geology Special Publication 89, p. 107-124.

Seni, S.J., and M.P.A. Jackson, 1983, Evolution of Salt Structures, East Texas Diapir Province, Part 1: Sedimentary Record of Halokinesis: American Association of Petroleum Geologists Bulletin, v. 67, p. 1219-1244. doi:10.1306/03B5B736-16D1-11D7-8645000102C1865D

Bureau of Economic Geology

Reservoir Characterization Research Laboratory

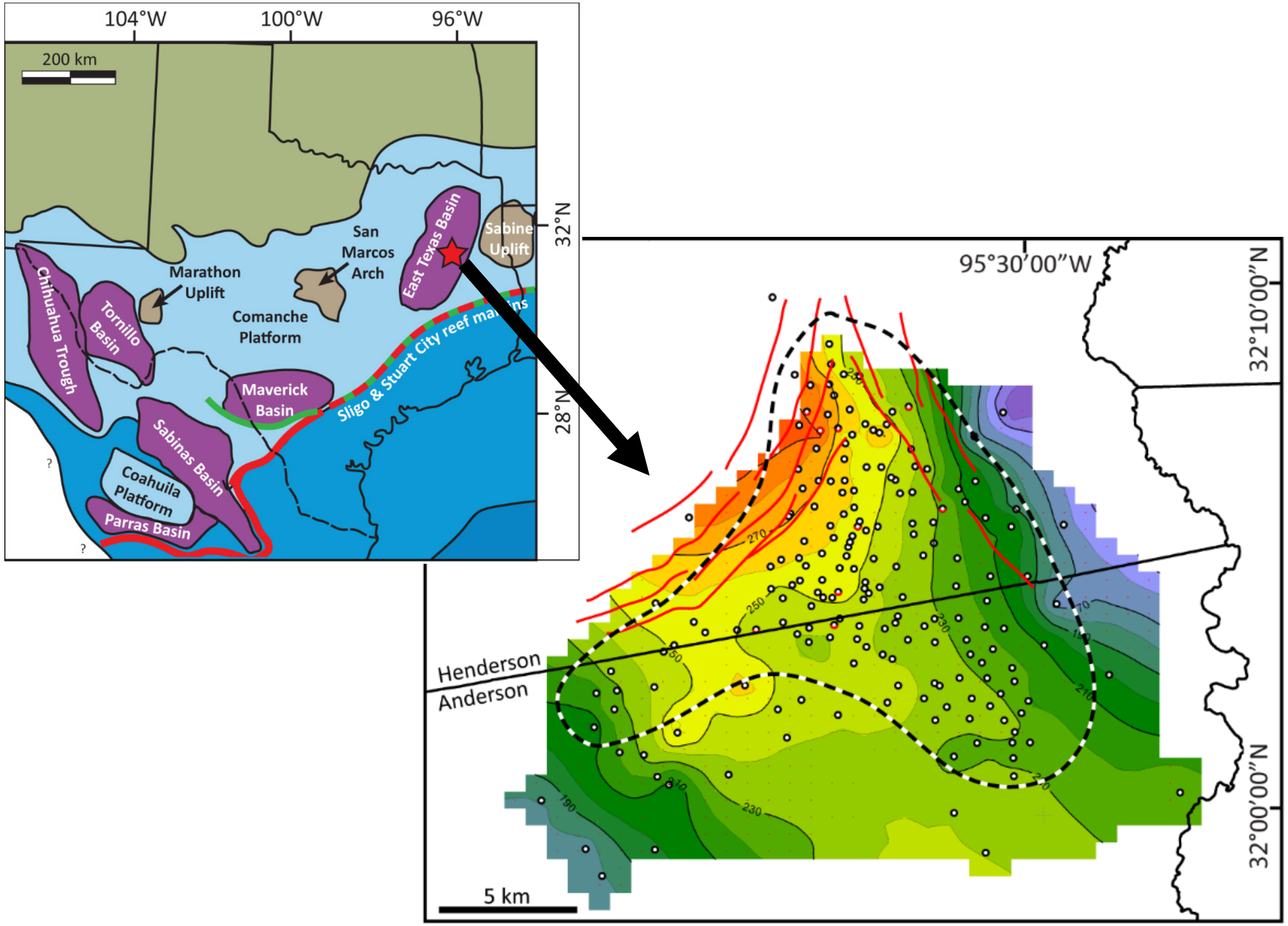
New model for halokinetically controlled patch reef systems:

A case study from the Fairway Field, a major Aptian reservoir in the East Texas Basin

KELLY E. HATTORI,

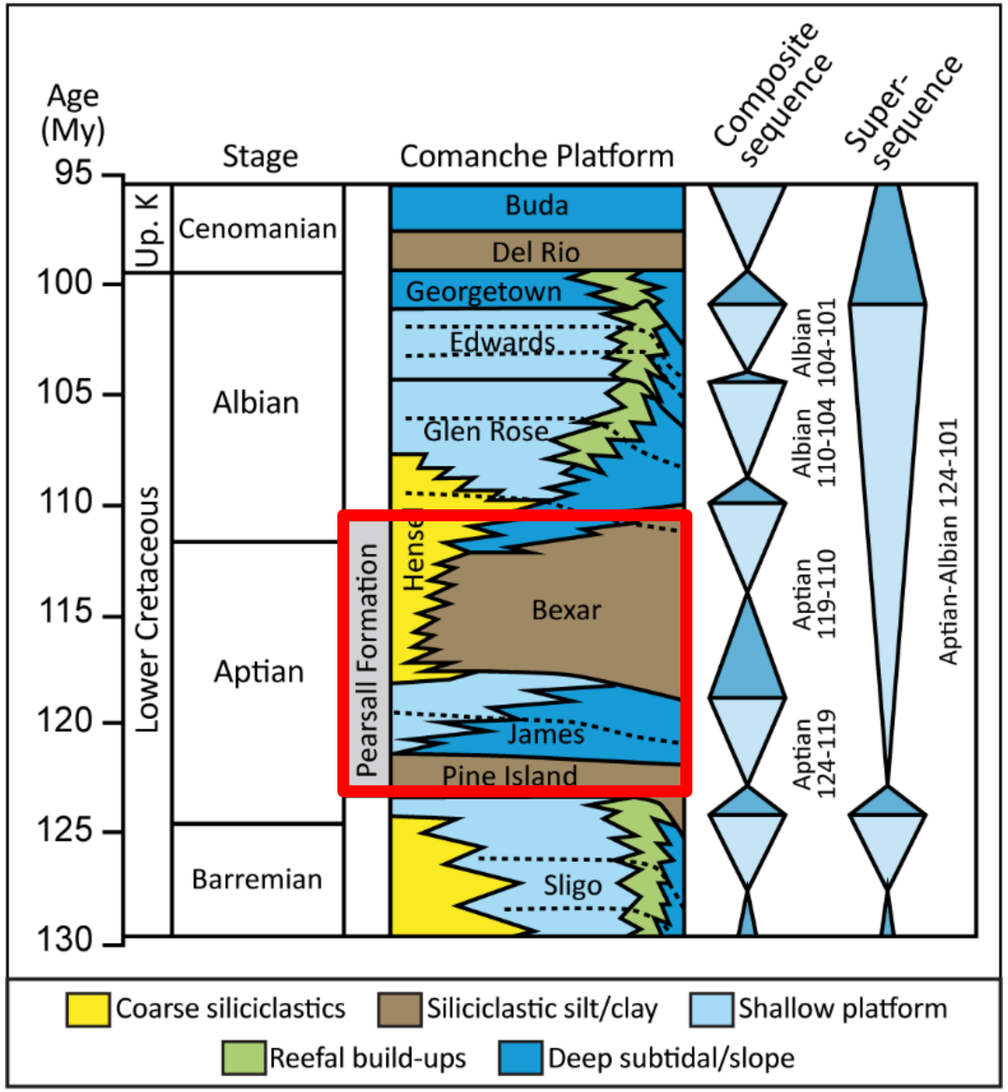
ROBERT G. LOUCKS, & CHARLES KERANS

Introduction to the Fairway Field



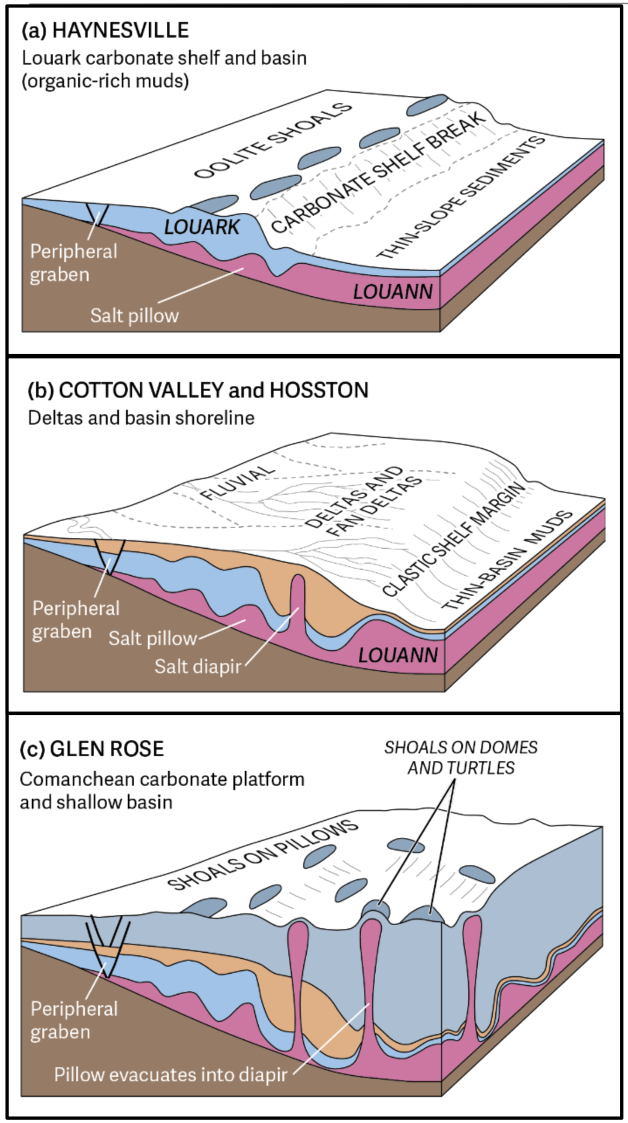
- Large (115 sq.km., 410 MMBO) O&G field discovered in 1960 in the East Texas Basin
- Wells produce from a reef complex in the James Limestone (Aptian-age Pearsall Formation)
- Best reservoir facies are reef-associated grainstones
- Combination stratigraphic/structural trap

Interest

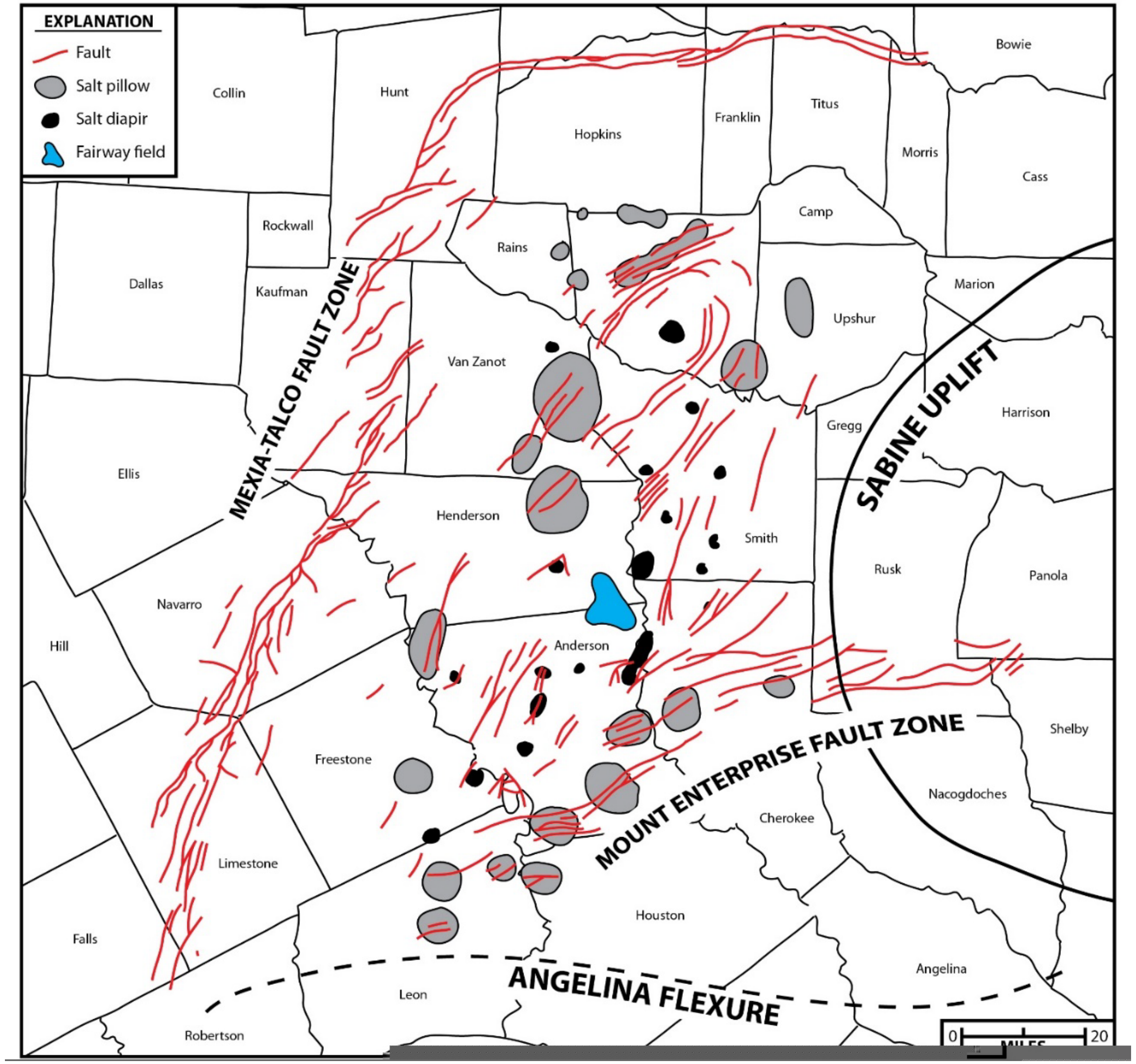


- Pearsall Formation has the benefit of good stratigraphic seals in the form of tight shales above (Bexar) and below (Pine Island) potentially good carbonate reservoir (James)
- Fairway Field is a major O&G field with complex stratigraphy – significant potential for improving exploration efforts with greater understanding of this field's stratigraphic architecture
  - Complex lateral/vertical heterogeneity
  - Impact of local halokinesis not clear
  - No sequence stratigraphic framework (no sense of timing of deposition)

Regional Context / Structure



Ewing (2016)

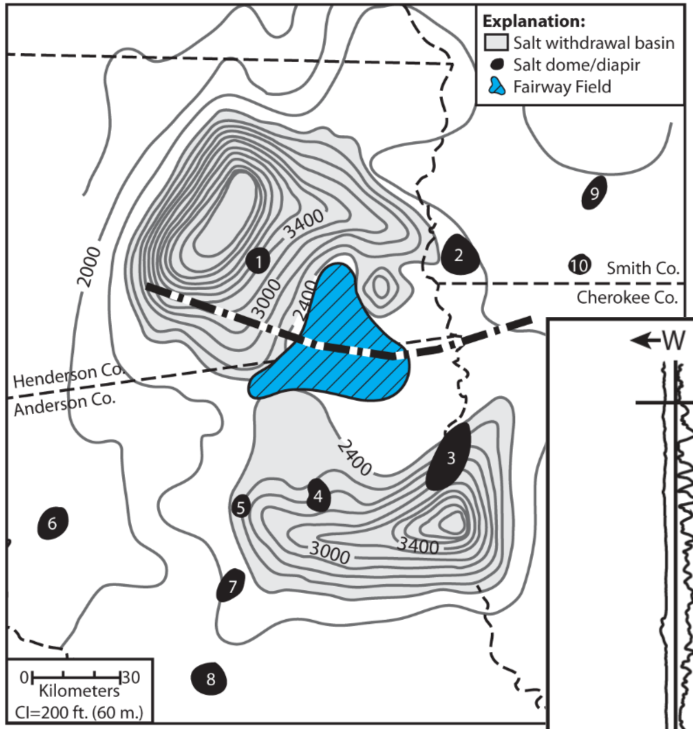


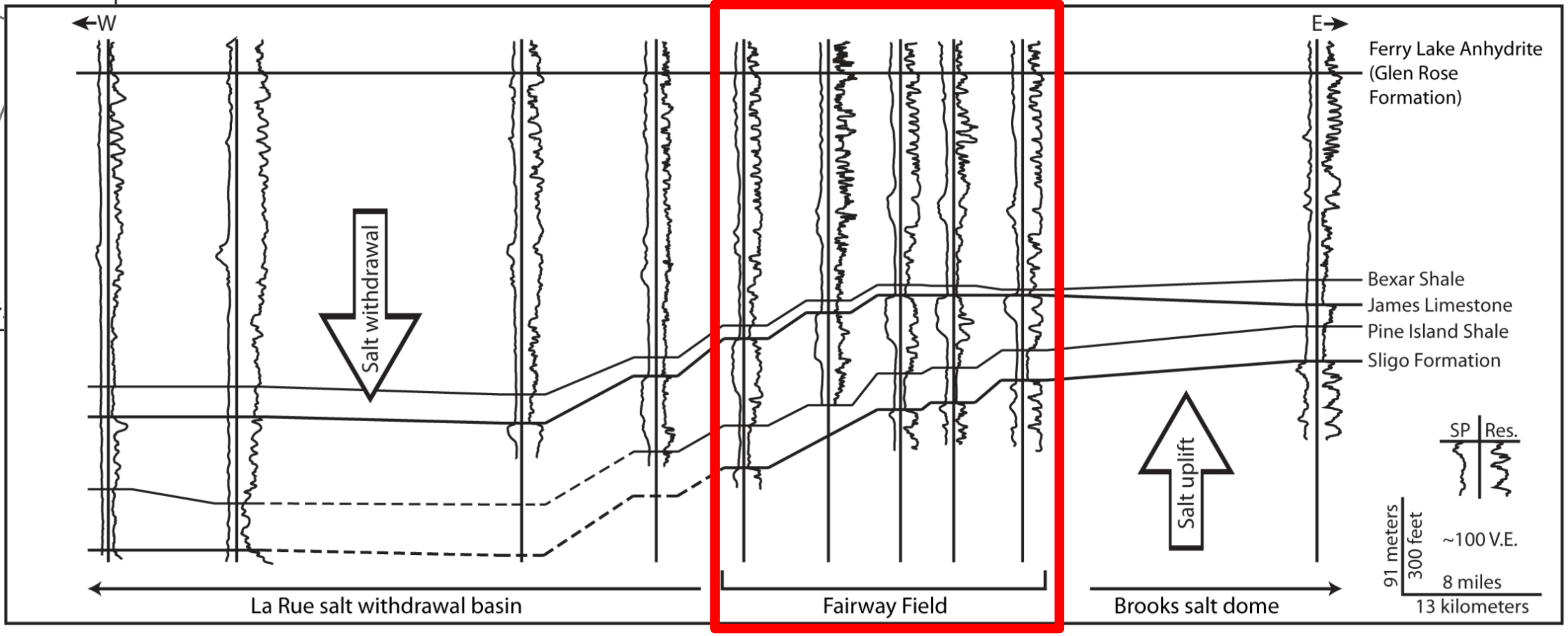
After Seni and Jackson (1983)

- East Texas Basin architecture modified by halokinesis of underlying Jurassic Louann Salt
- Diapirism occurred throughout Cretaceous
- Carbonates (shoals, biostromes, reefs, etc.) developed on and around salt domes

Regional Context / Structure

- Fairway Field proximal to four salt domes / withdrawal basins
- Wireline correlation shows significant topography generated by salt movement





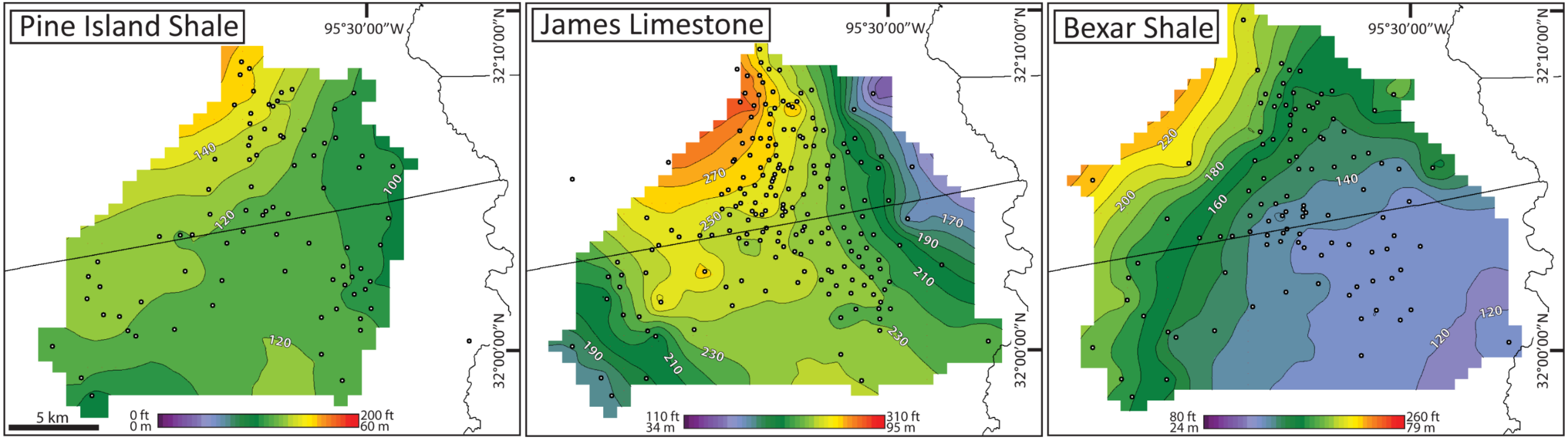
Questions

- How did the underlying halokinetically-modified topography affect depositional setting in the James Limestone reef complex in the Fairway Field?

- With that improved understanding, can we build a sequence stratigraphic framework that better explains distribution of reefs and productive reef-derived grainstone facies?

- How does this change our understanding of reef association with halokinetic highs?

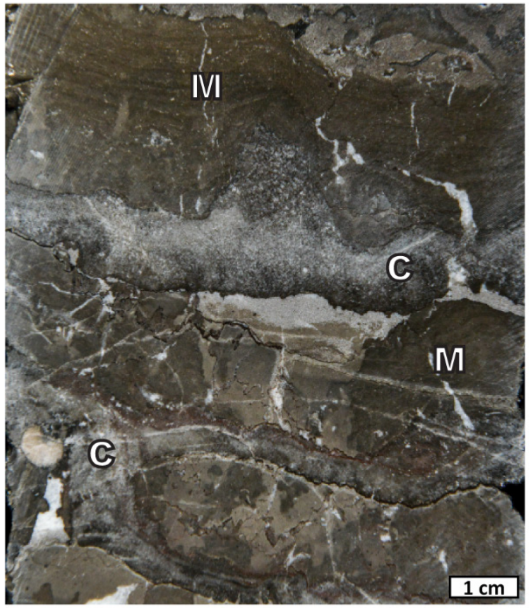
Isopach Maps

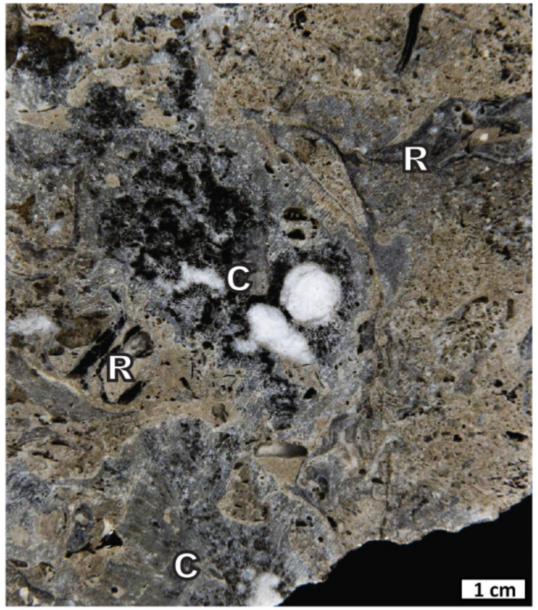


- All three units thicken to the NW – topographic low present (La Rue salt withdrawal basin)
- Pine Island and James thin SW/NE with an embayment where the Fairway Field is located
- Bexar does not show evidence of embayment or substantial thinning SW/NE – topography was filled during James deposition

Facies Groups

Reef facies





Deep reef

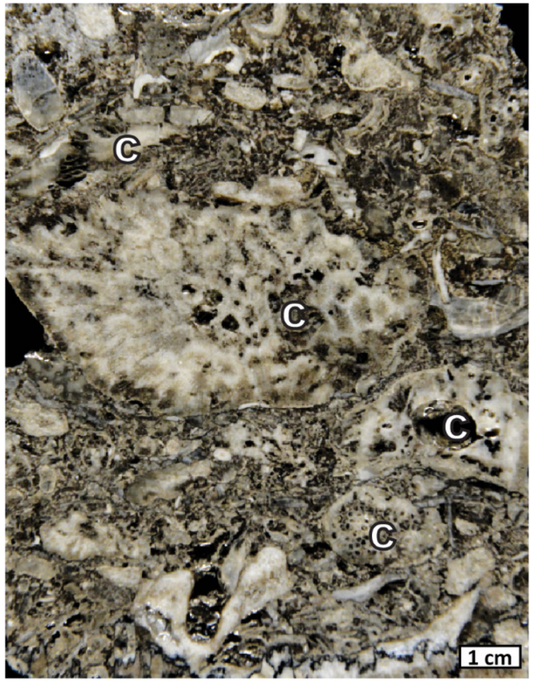
- Platy coral (*Microsolena*)
- Microbial mats
- Mud matrix
- Low por/perm

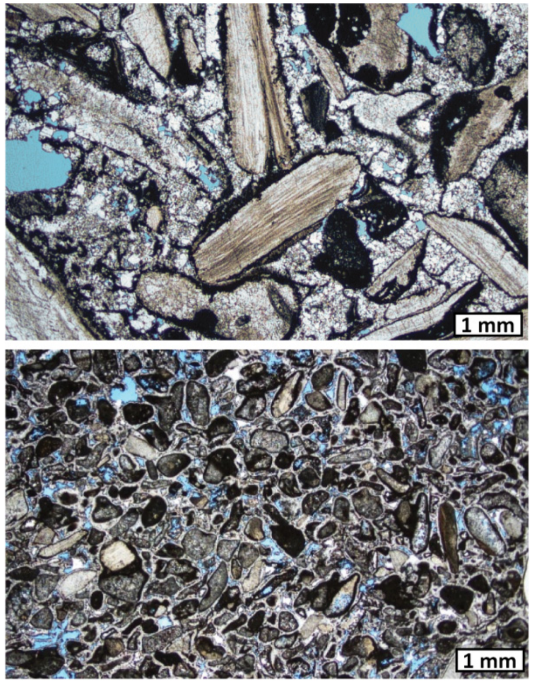
Shallow reef

- Corals, stromatoporoids, rudists, chondrodonts
- Coarse skeletal grain matrix
- Mod-high por/perm

Grainstone facies

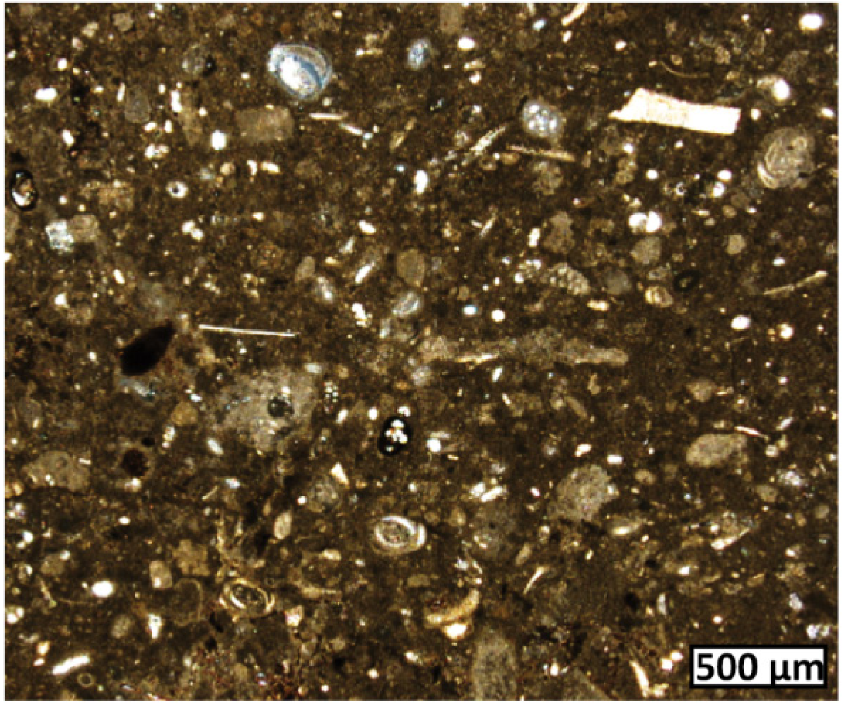
- Mostly reef-derived grains (coral, rudist, chondrodont, stromatoporoid fragments)
- Grain size ranges from dm-scale (proximal to reef) to mm-scale (distal)





Facies Groups

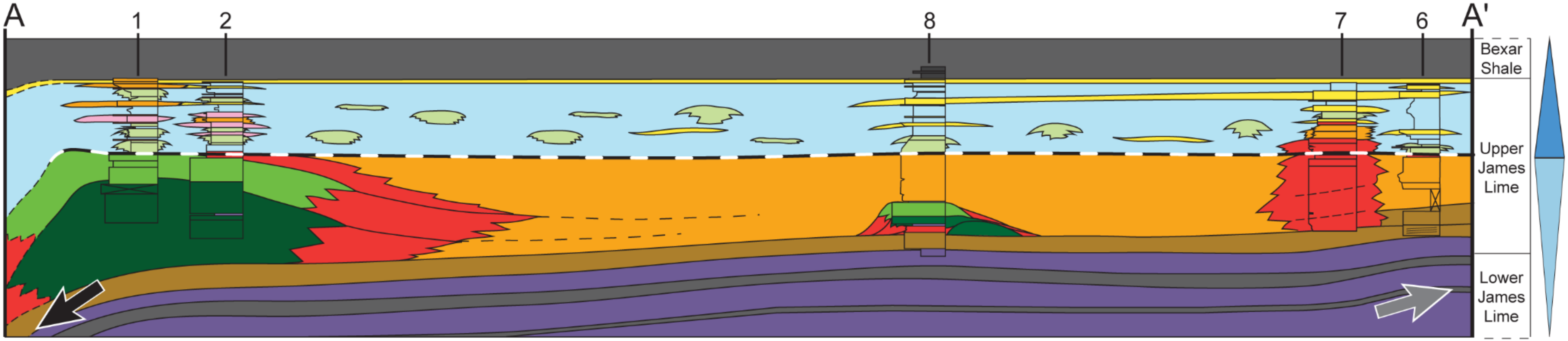
Low energy, shallow shelf facies

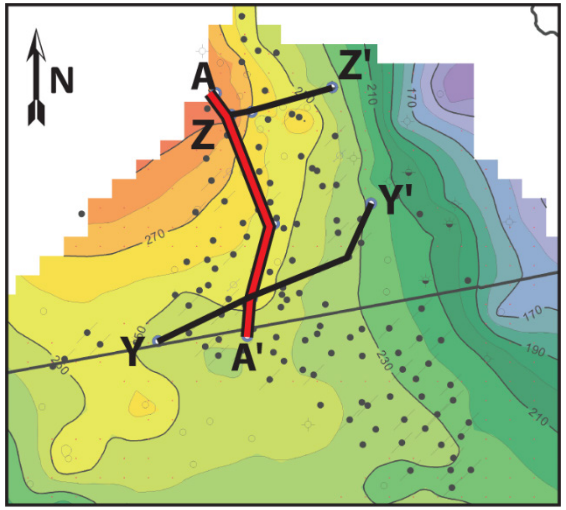


Miliolid-skeletal-peloid wackestone/packstone

Rudist & chondrodont biostrome

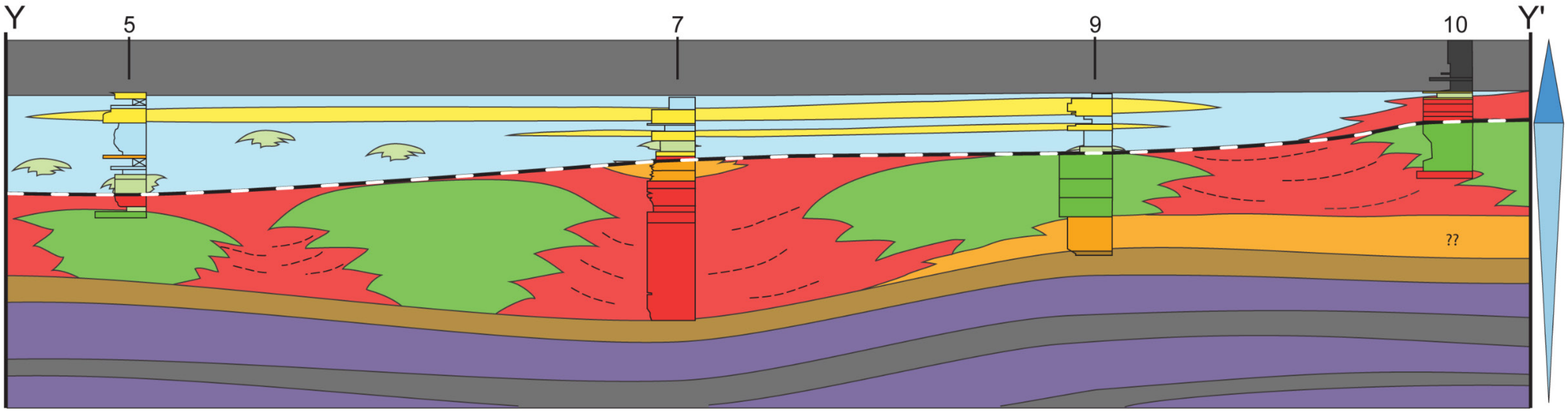
Cross Section A-A’

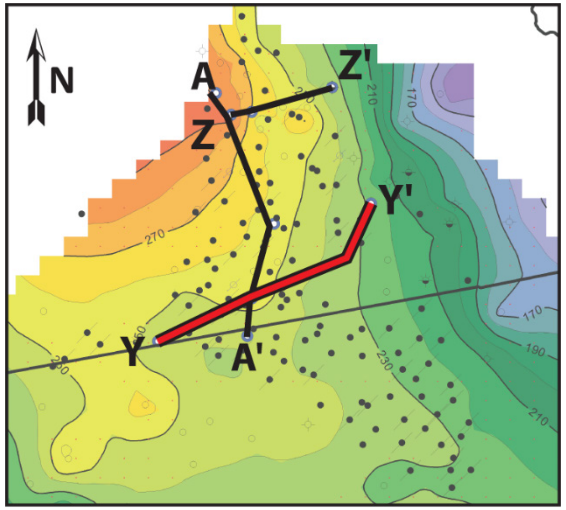




- Large reef buildups to the north, smaller buildups to south
- Reef-derived grainstones (orange/red) adjacent to reefs
- Erosional contact at top of reefs/grainstones before deposition of overlying low-energy miliolid-oyster wackestone/packstones (blue)
- Overlying low-energy facies are uniform thickness across cores

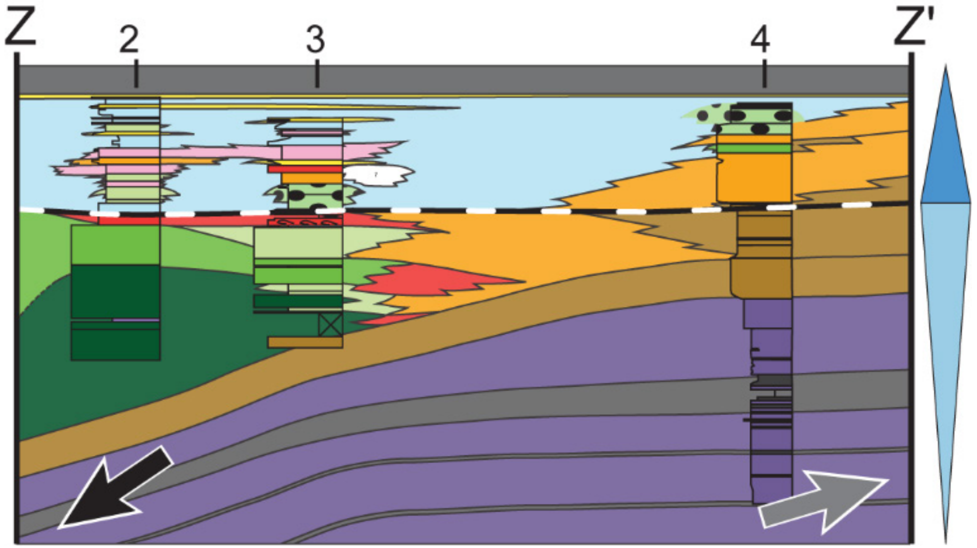
Cross Section Y-Y’

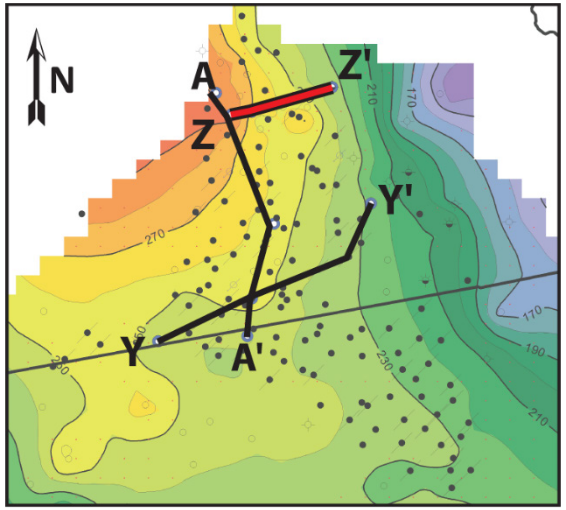




- Cores alternate between shallow, high energy reefs (green) and reef-derived rudstones (red)
- Interpretation: trend of scattered patch reefs in a shallow environment with sand chutes between the buildups

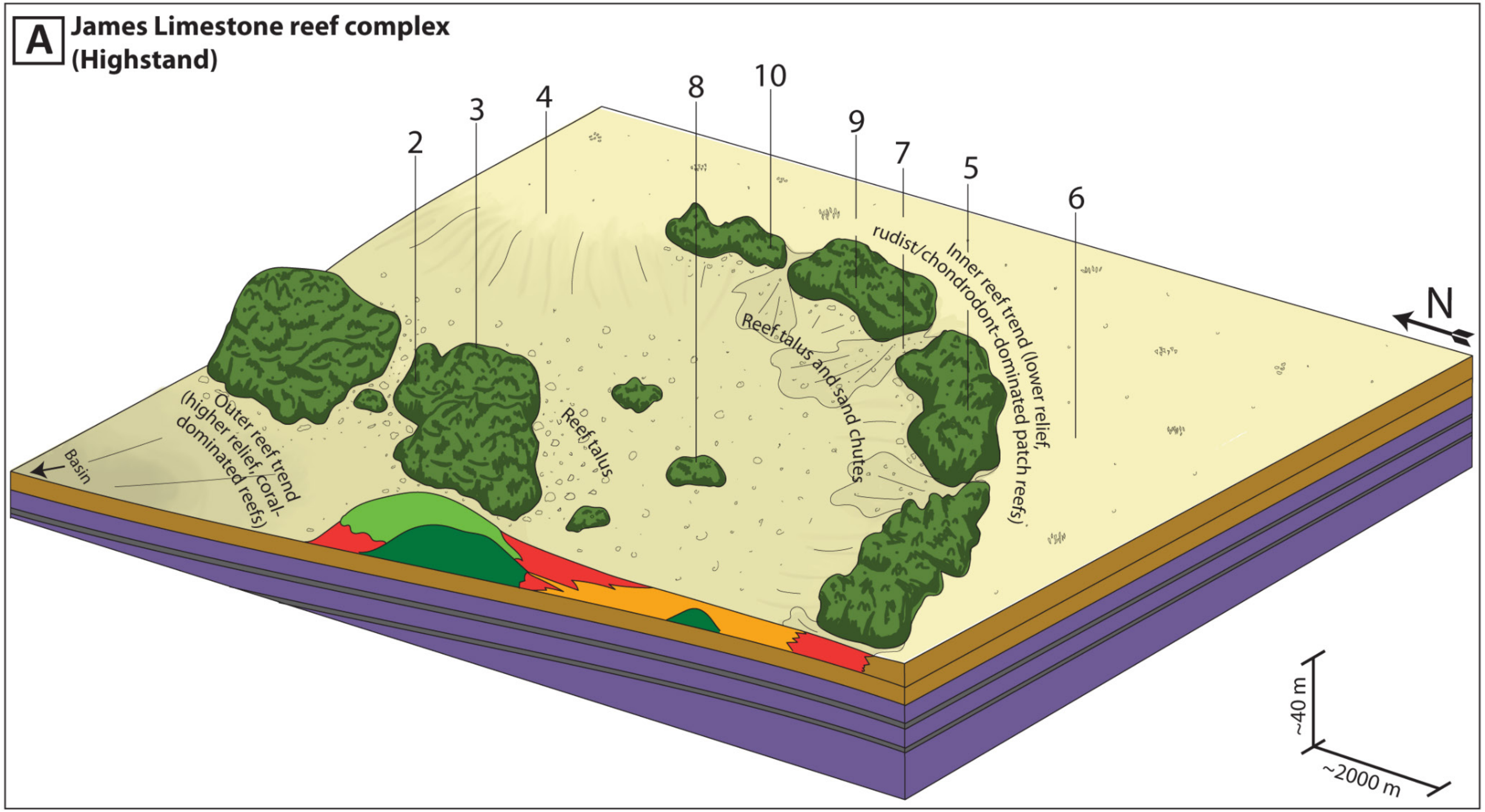
Cross section





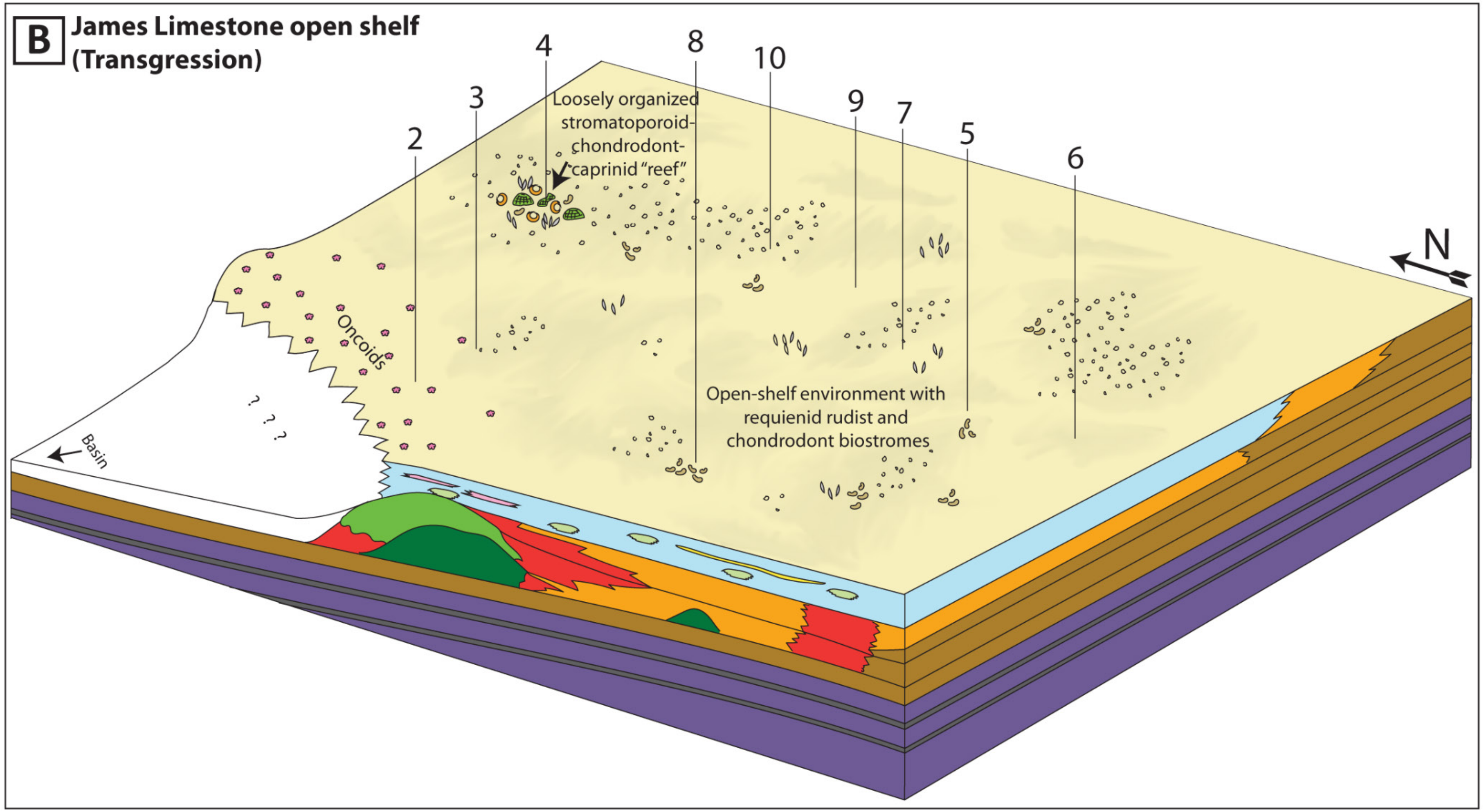
- Steeper slope in topography at northern end of field – more rapid facies shifts due to steeper slope into basin and topographic high to the east
- Transgressive succession has some packstones and grainstones on the eastern side of cross section, reflecting increased energy at topographic high

Snapshots in Time



- Larger reefs adjacent to basin were barriers for sediment
- Sediment accumulated in the area between the topographic high and the reefs

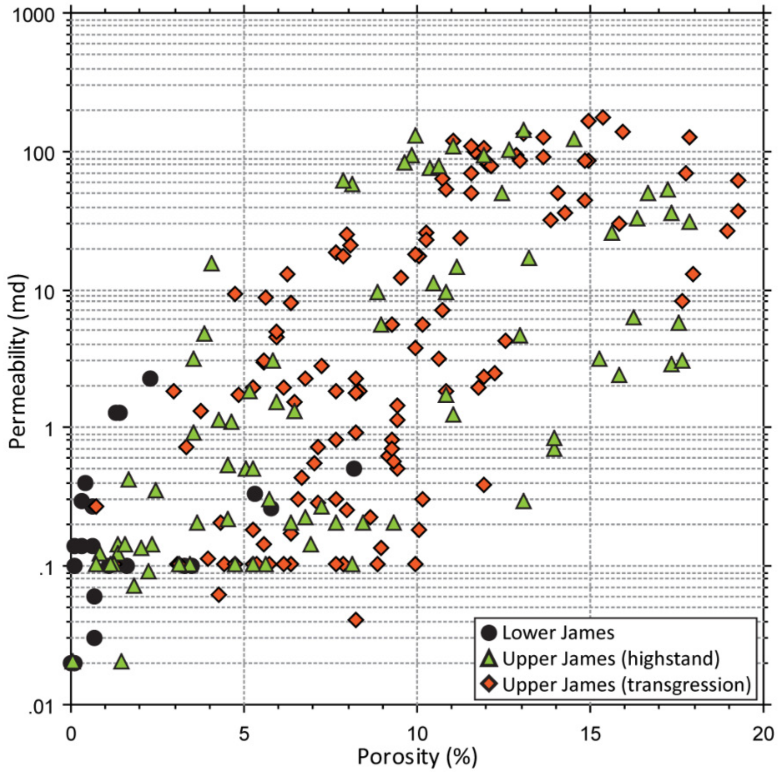
Snapshots in Time



- No evidence of underlying topography
- Low energy open shelf facies dominate
- Scattered small-scale reefs and biostromes

Impact on Porosity/Permeability

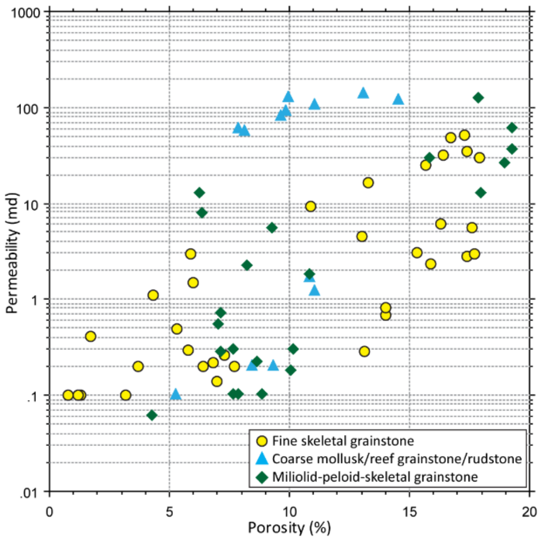
Porosity/permeability by sequence



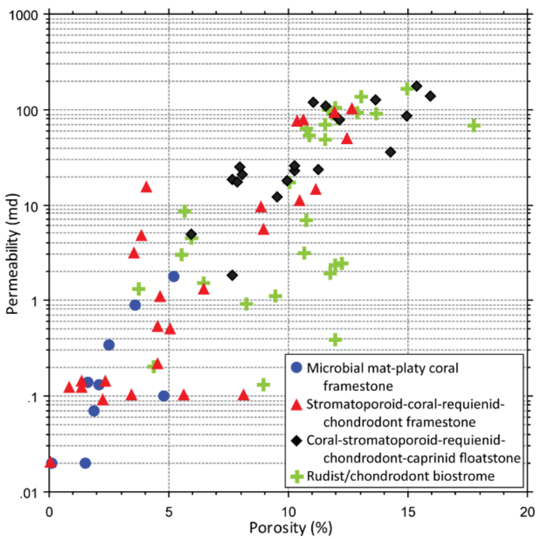
- Core porosity and permeability measurements from the highstand succession and the transgressive succession overlap nearly identically
- However, the most productive units are from lower in the James (in the highstand succession) – why?

<u>Has to do with facies distribution and connectivity!</u>

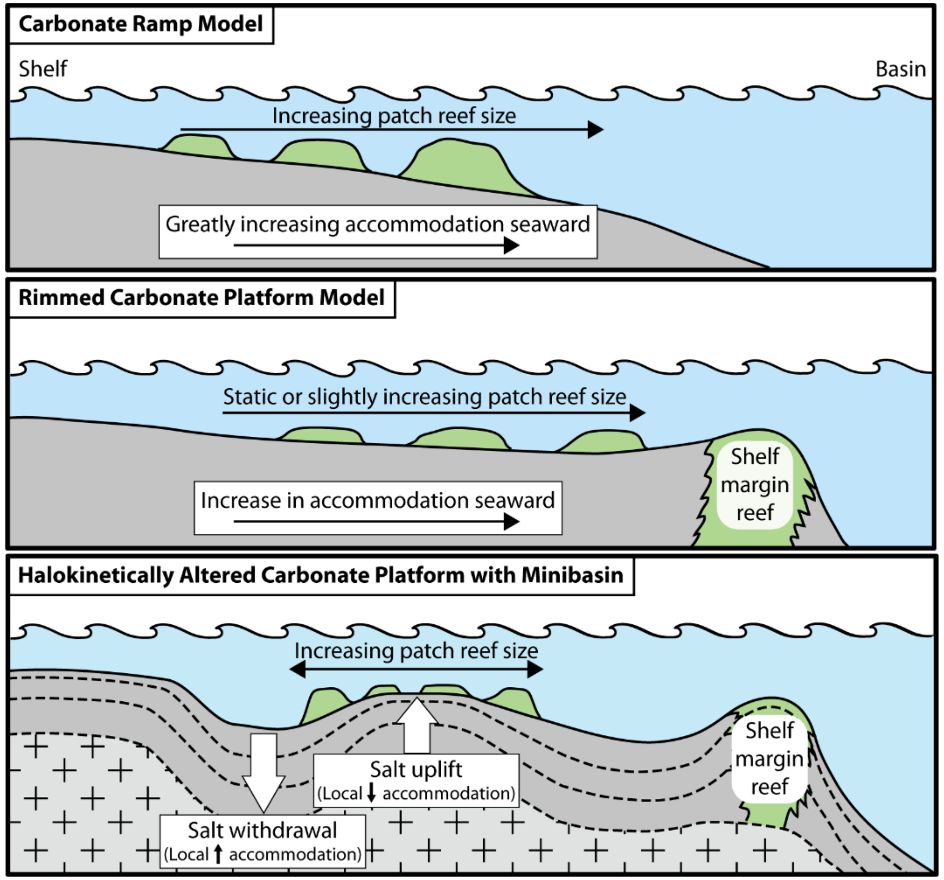
Porosity/permeability of grainstone bodies



Porosity/permeability of reefs

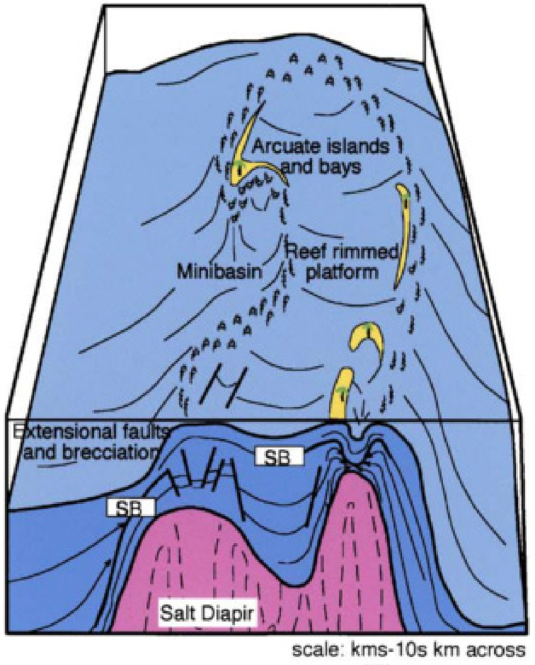


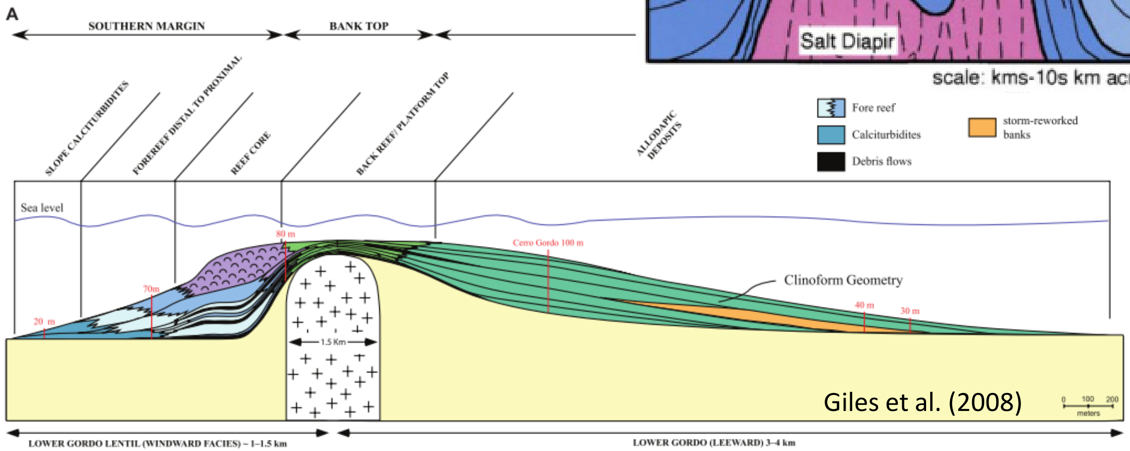
Applications



- Halokinesis can impact predictions of reef size/distribution counterintuitive to commonly-used carbonate ramp/rimmed platform models
- Carbonates on salt domes in intrashelf basins have different facies relationships and reef growth than other halokinetic carbonate models

B. Salt-Diapir Platform
Bosence (2005)





Giles et al. (2008)

Conclusions

- Halokinetic activity set up a topographic high that reefs grew around adjacent to a topographic low (La Rue salt withdrawal basin)
- Facies in the Fairway Field can be separated into a highstand systems tract and a transgressive systems tract
  - Highstand – Reefs develop, erosion/shoaling
  - Transgression – Blanketing low-energy shallow shelf facies with scattered biostromes
- Best reservoir facies are in the highstand grainstones because they have greatest distribution in addition to good porosity/permeability
- Halokinetically modified topography in an intrashelf basin is associated with different carbonate facies distributions than mapped in isolated salt diapirs
- Reef distribution and size is dependent on local topography - care should be taken when predicting locations of reef growth within intrashelf salt basins

References

- Bosence, D., 2005, A genetic classification of carbonate platforms based on their basinal and tectonic settings in the Cenozoic: Sedimentary Geology, v. 175, p. 49–72, doi: 10.1016/j.sedgeo.2004.12.030.
- Ewing, T.E., 2016, Texas Through Time: Lonestar Geology, Landscapes, and Resources: The University of Texas at Austin, Bureau of Economic Geology, 431 p.
- Giles, K.A., Druke, D.C., Mercer, D.W., and Hunnicutt-Mack, L., 2008, Controls on Upper Cretaceous (Maastrichtian) heterozoan carbonate platforms developed on salt diapirs, La Popa Basin, NE Mexico, *in* Lukasik, J. and Simo, J.A.T. (eds.), Controls on Carbonate Platform and Reef Development: Society for Sedimentary Geology Special Publication 89, p. 107–124.
- Seni, S.J., and Jackson, M.P.A., 1983, Evolution of salt structures, East Texas Diapir Province, Part 1: Sedimentary record of halokinesis.: American Association of Petroleum Geologists Bulletin, v. 67, p. 1219–1244, doi: 10.1306/03B5B736-16D1-11D7-8645000102C1865D.