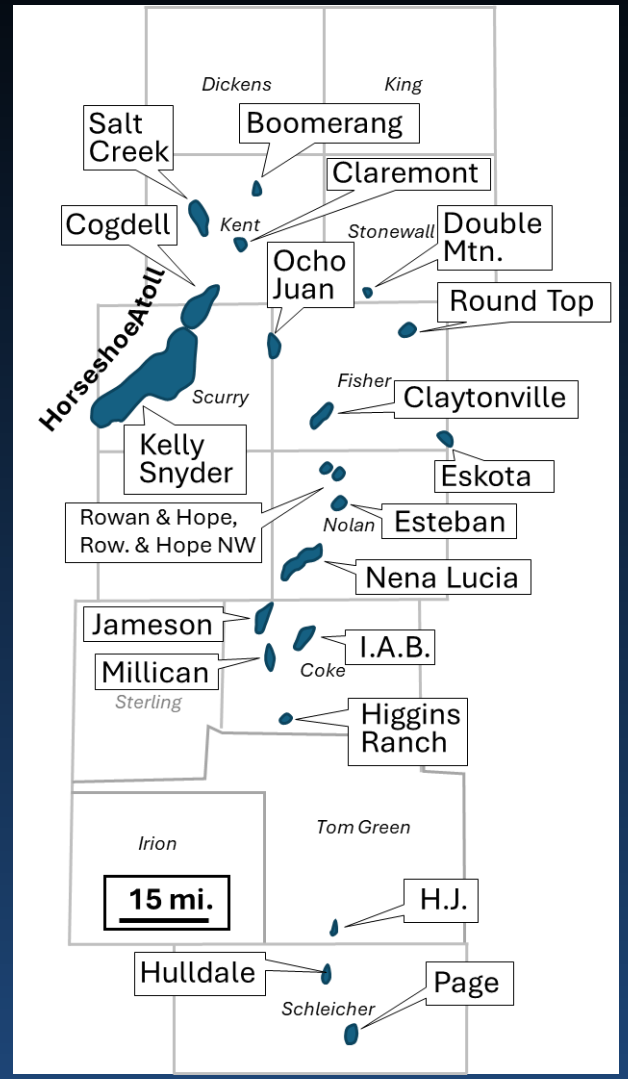
Pennsylvanian reefs of the Eastern Shelf: What do we *really* know?

Lowell Waite

Dept. of Sustainable Earth Systems Sciences
Permian Basin Research Lab
University of Texas at Dallas



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Summary

What do we *really* know about Pennsylvanian (Penn) reefs of the Eastern Shelf?

- A lot
- Upon further review: We still have much to learn

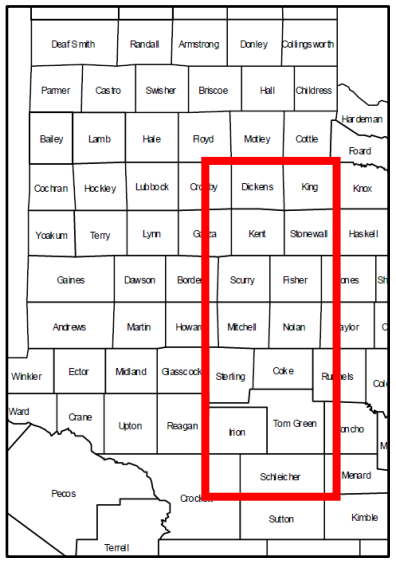
Outline

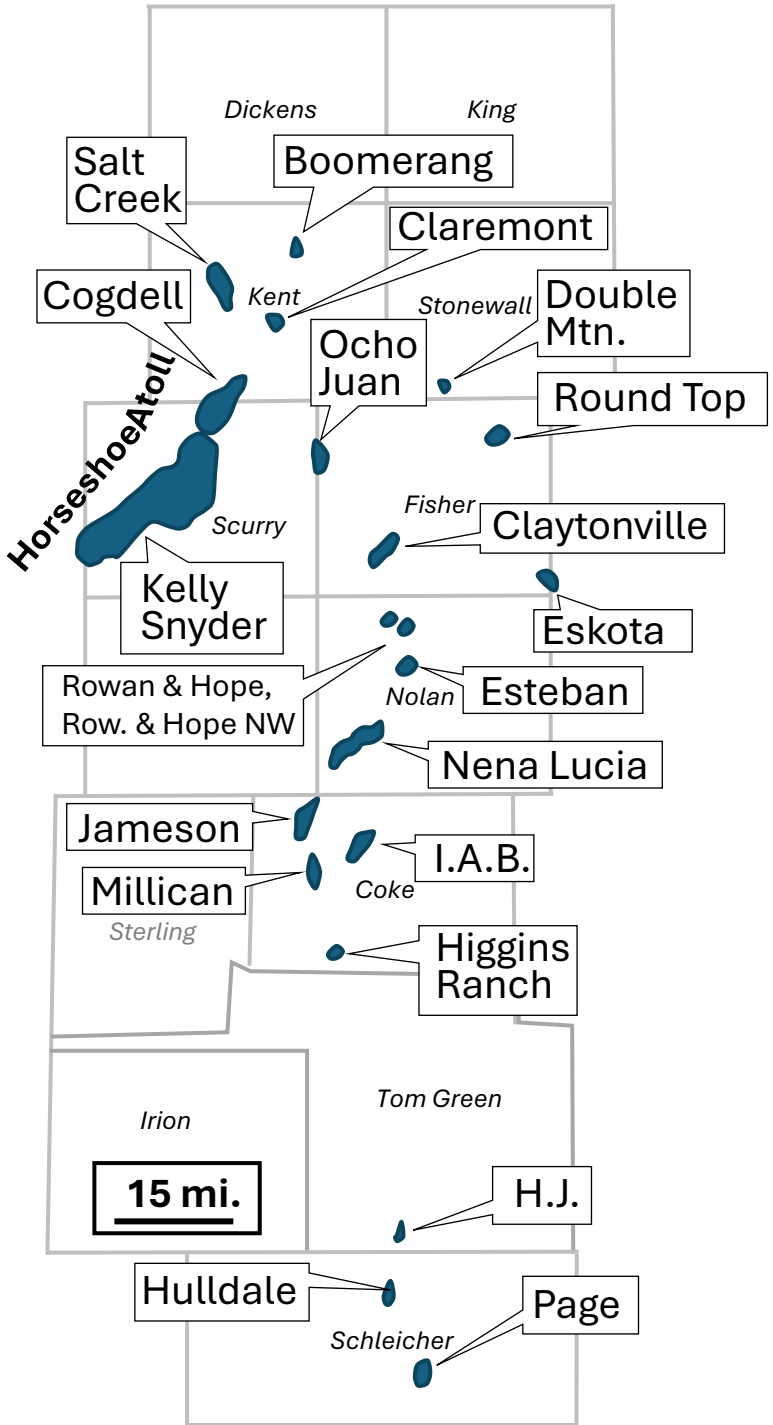
- Overview of Penn reefs of Eastern Shelf
  - Trend map
  - Reefs (?) or what ?
  - The data problem: lack of deep well control and 3D seismic coverage
- Comparison of reef sizes and orientations
- Reef topography: the role of sea-level change vs. erosion

Maximizing future reserves requires accurate geologic / reservoir models

Pennsylvanian Reef Trend of the Eastern Shelf

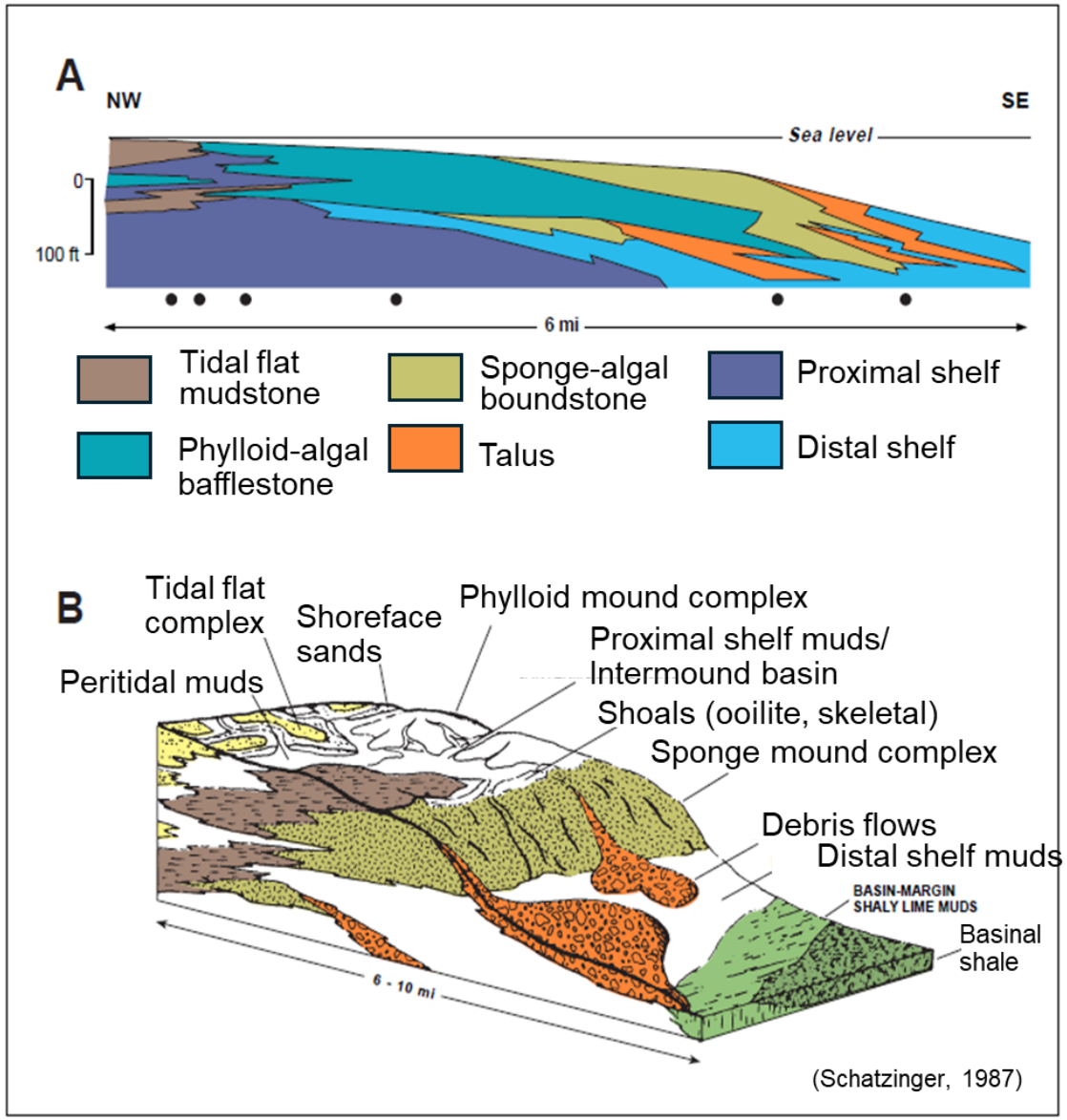
(from Counselman, 1960)



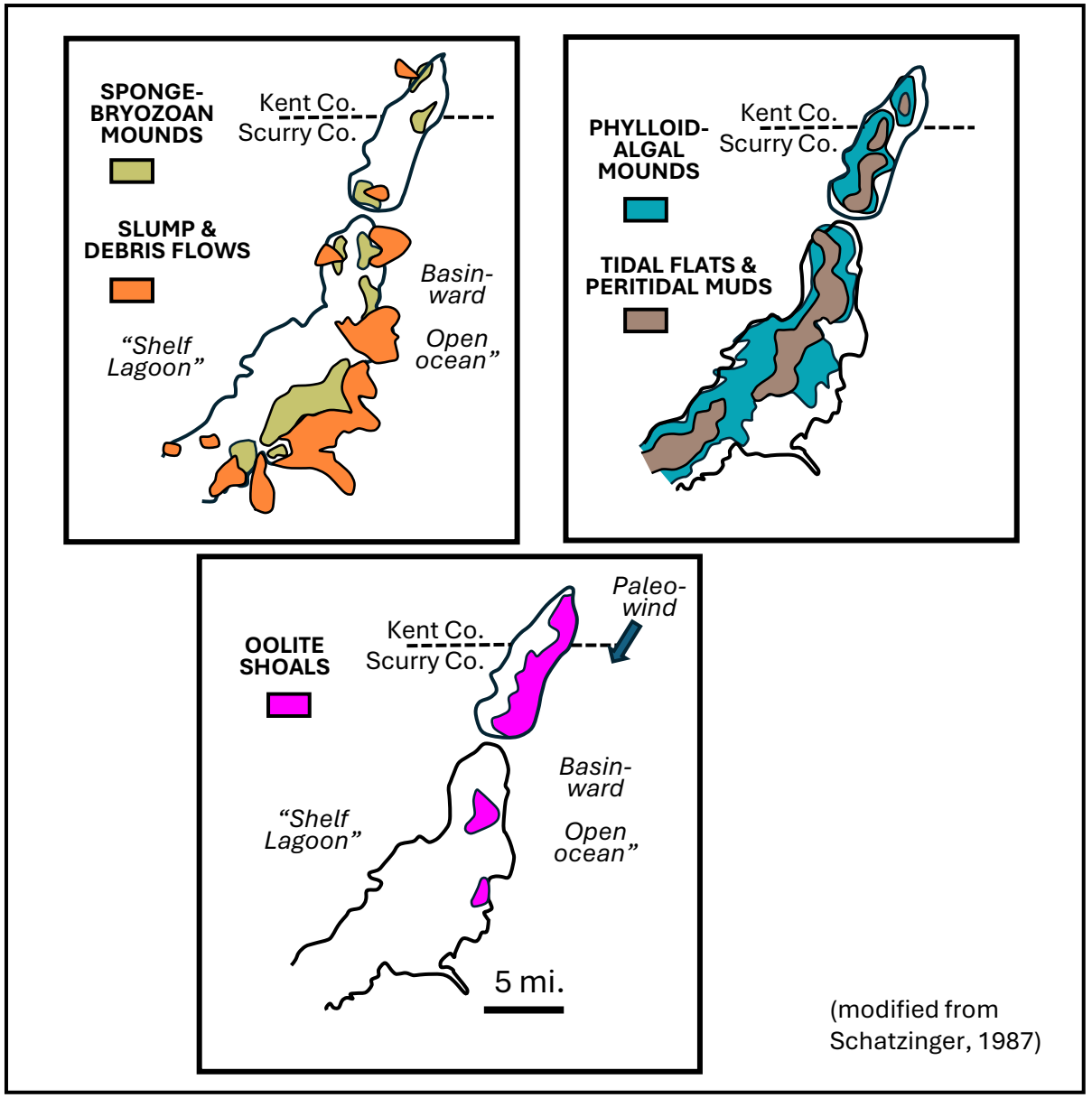


- String of individual reefs stretching more than 300 miles long and 60 miles wide (480 x 100 km)
- Note that this map is incomplete, only showing most of the larger reef fields
- Facies analysis show that these “reefs“ are actually carbonate buildups or masses with a diverse number of facies

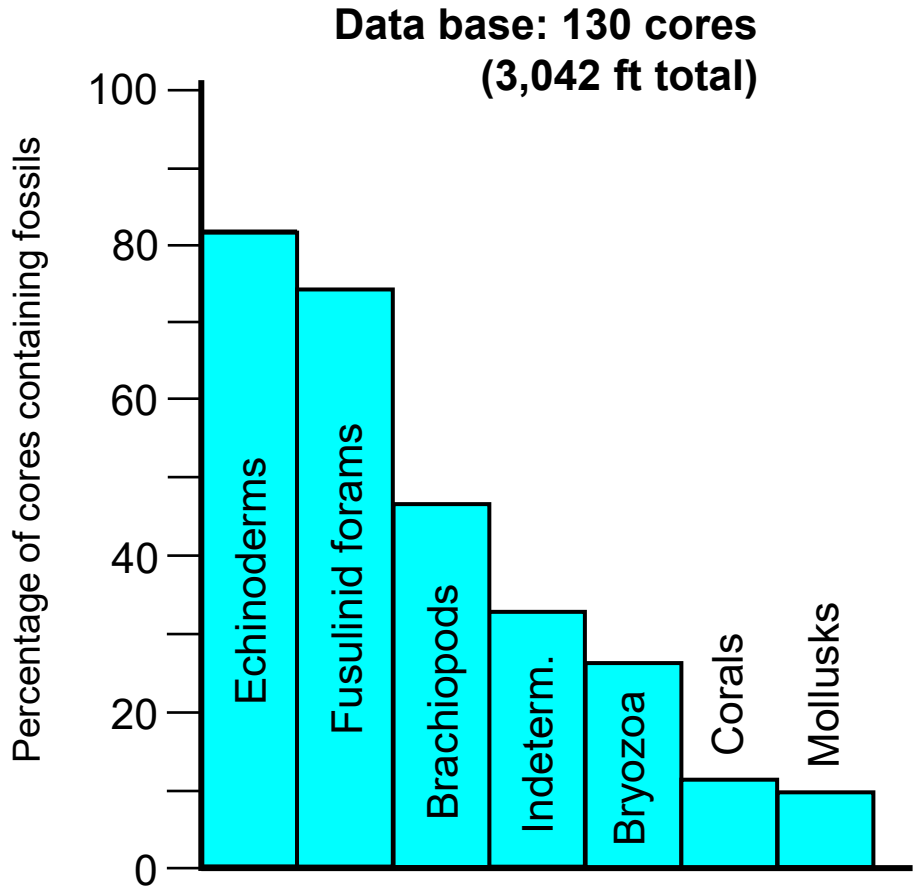
Reef of the eastern side of the Horseshoe Atoll (SACROC, Diamond M, Cogdell, Salt Creek) remain the most studied, providing insight to ES reefs



- Schatzinger (1987) notes that buildups at SACROC are a stacked series of a variety of facies, including tidal flat, ooid/skeletal grainstones, and phylloid algal and sponge reefs



Major non-algal / non-sponge fossil constituents of the Atoll



Note: ooids constitute a large % of grain types in places along outer margin of Atoll

Carbonate rock types

- Grainstone: 46.3%
- Packstone/ Wackestone/ Mudstone 35.2%
- Rudstone (debris flows) 15.9%

97.4% $CaCO_3$

- Shale 2.6%

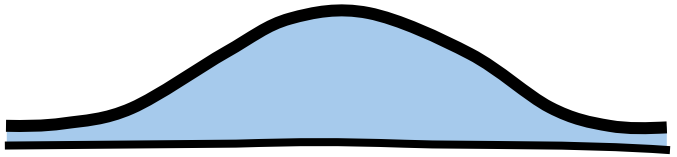
(data from Myers et al., 1956; Bergenback and Terriere, 1953; Schatzinger, 1983)

Reefs ? or what ?

- Clearly, the term “reef” an oversimplification for these carbonate masses

- Better terms might include “reef complexes,” “carbonate buildups,” “reef-shoals,” or “reef-mounds”

  - Main characteristics:
    - isolated, positive topographic relief
    - myriad of carbonate facies



-- OK to call them reefs, but remember the complexities of these carbonate masses--

REEFING REVISITED, or
A Reef is A Reef is a Reef
By:
Frank B. Conselman
Consulting Geologist
Ransom Canyon, Texas

(Abilene Geol. Soc., 1983)

Outline

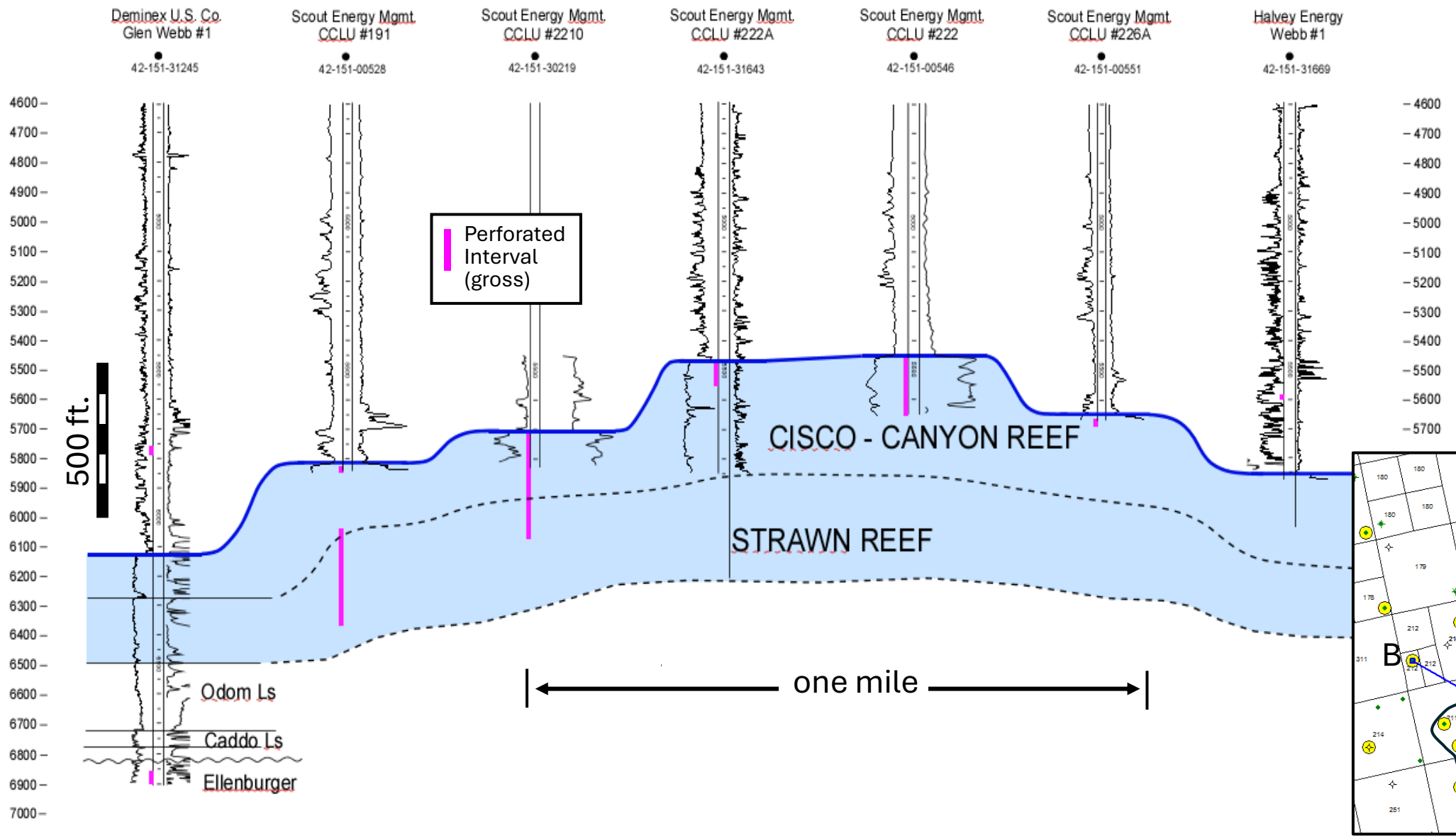
- Overview of Penn reefs of Eastern Shelf
  - Trend map
  - Reefs ?
  - **The data problem: lack of well control and 3D seismic**
- Comparison of reef sizes and orientations
- Reef topography: the role of sea-level change vs. erosion

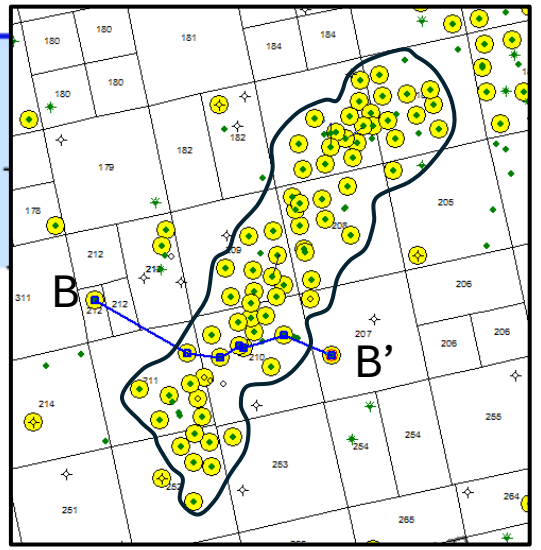
Penn reefs of the Eastern Shelf: The data problem

- Most, if not all reefs on the Eastern Shelf lack wells that completely penetrate the buildups in their highest (thickest) portions
- Consequently, defining the top the reef using well logs is not a problem; but accurately characterizing internal structure/correlation requires 3D seismic; not all are imaged
- Historically, deeper zones within these reefs are considered “wet” without the benefit of full suites of deep, modern logs
- Could deeper pay zones exist, particularly within the Strawn ?

Claytonville Reef, Fisher County

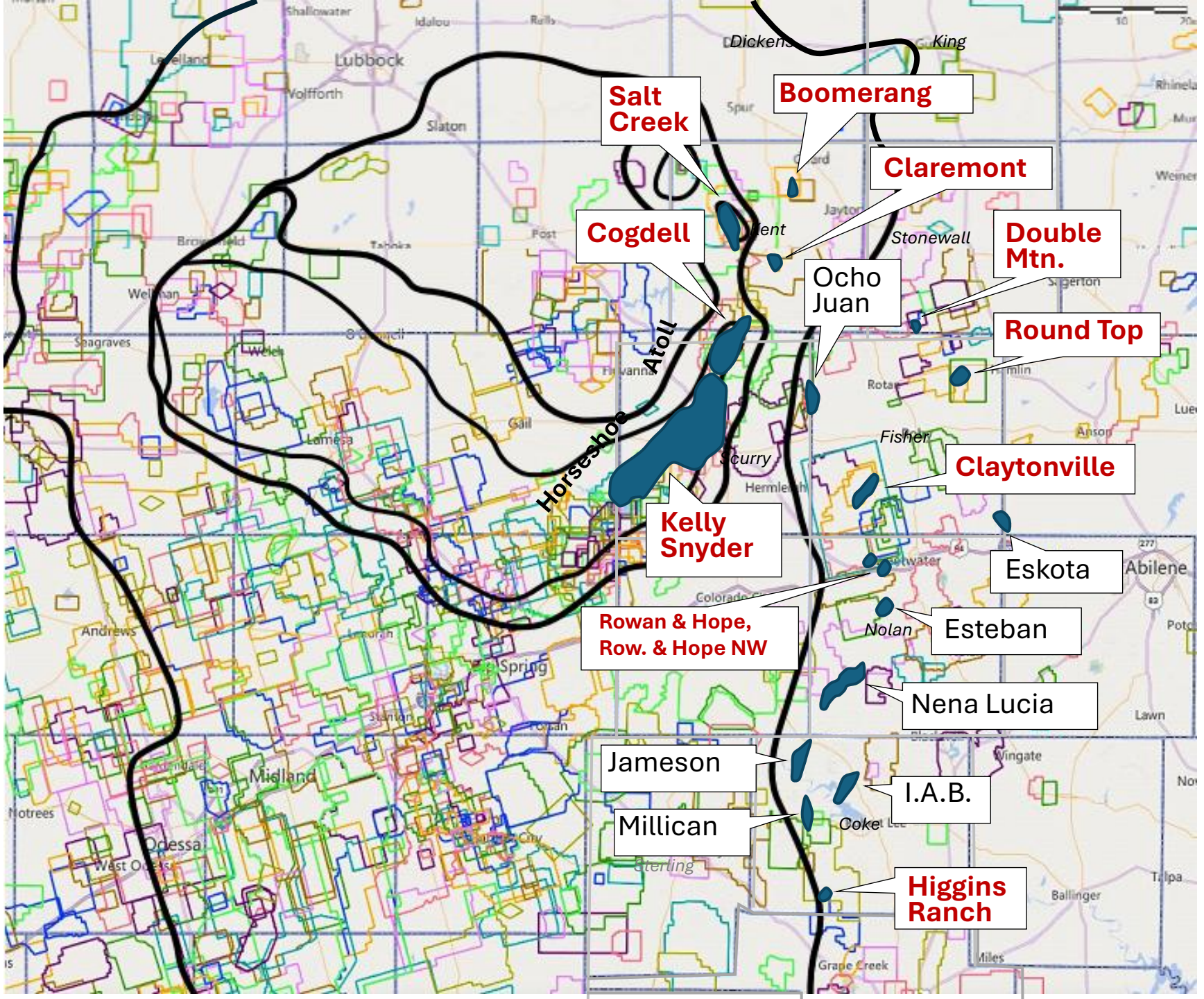
West B — B' **East**





Note lack of deep well control within reef

3D seismic required to interpret reef interior



3D seismic surveys

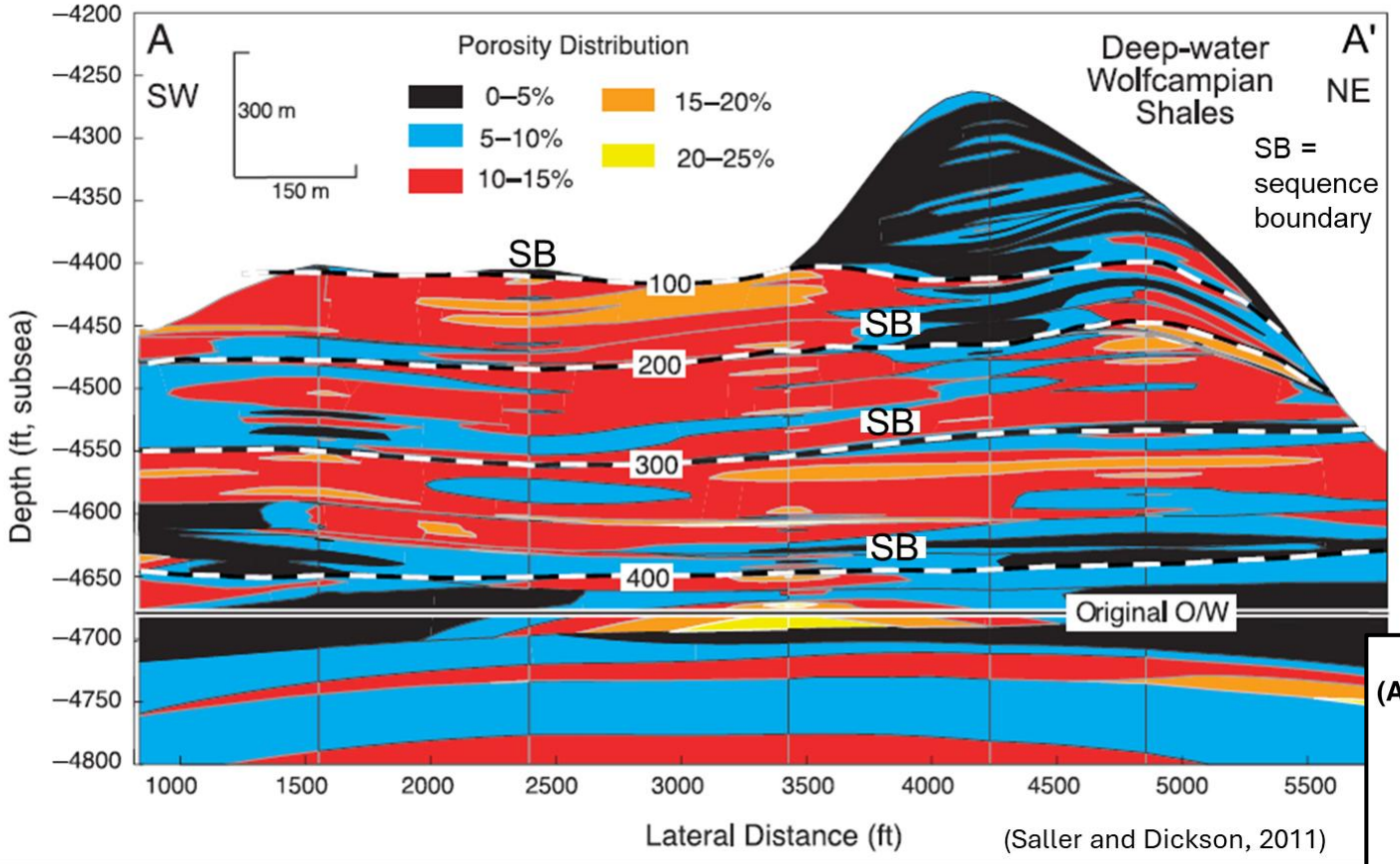
Midland Basin – Eastern Shelf

Seismic base map from SEI
https://www.seismicexchange.com

Note lack of data on Eastern Shelf vs. Midland Basin

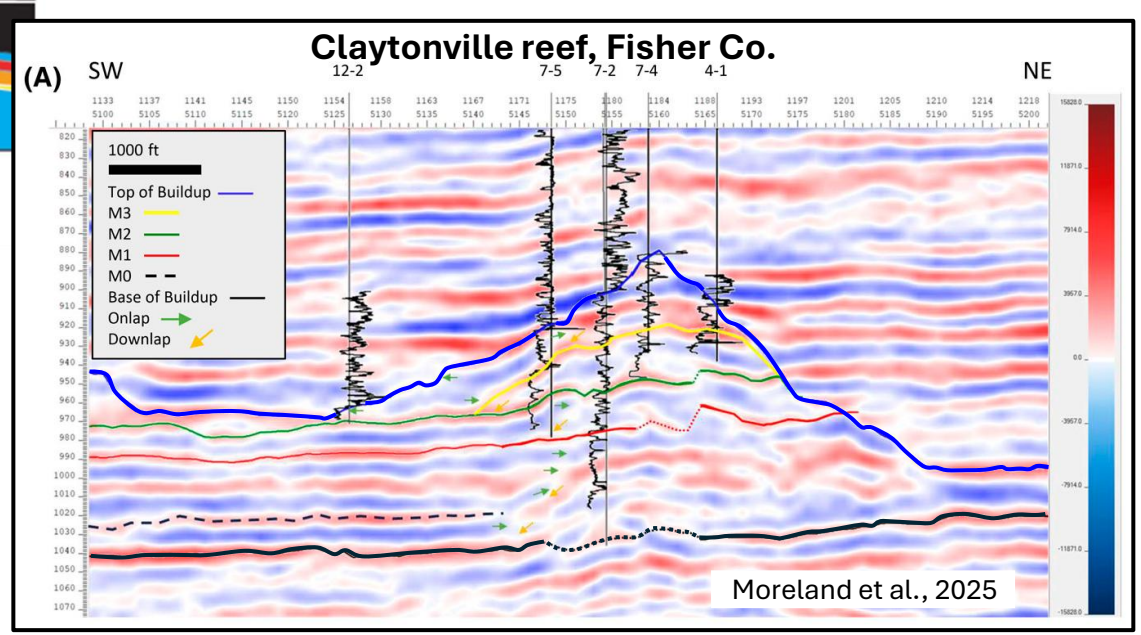
60% of reefs on Eastern Shelf covered by 3D seismic (highlighted in red font)

Internal complexity of Penn Reefs: Porosity distribution model, Reinecke Field (Borden Co., Horseshoe Atoll)



- Nature of Penn. cyclic carbonate deposition provides opportunities for stranded porosity and isolated, unproduced pay
- Note deep porosity below mapped O/W contact (100% wet ?)
- Application of horizontal drilling ??

3D seismic shows internal stratigraphic architecture and complexities of these buildups



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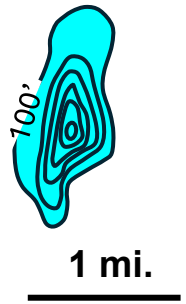
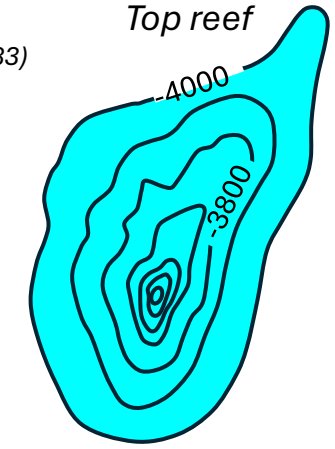
Higgins Ranch
Coke Co.
Isopach (c.i.=50')
(Mazzullo & Mazzullo, 1983)

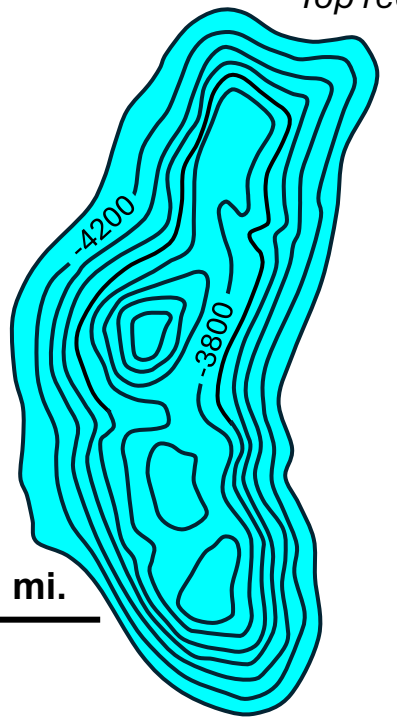


Rowan & Hope NW
Nolan Co.
Top reef

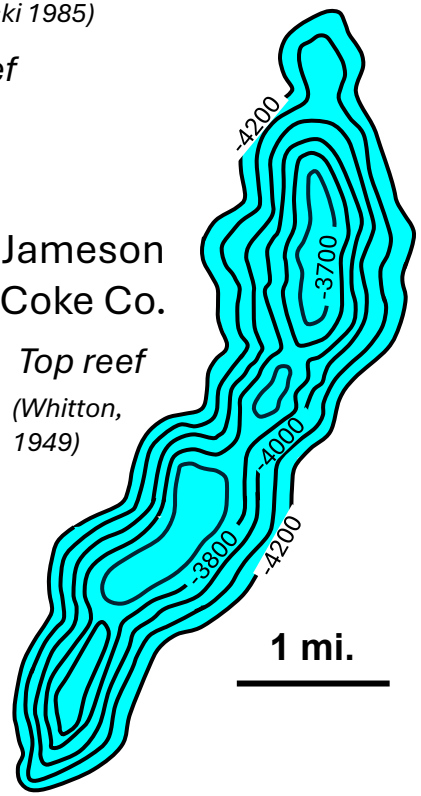


(Williams & Schatz, 1956)

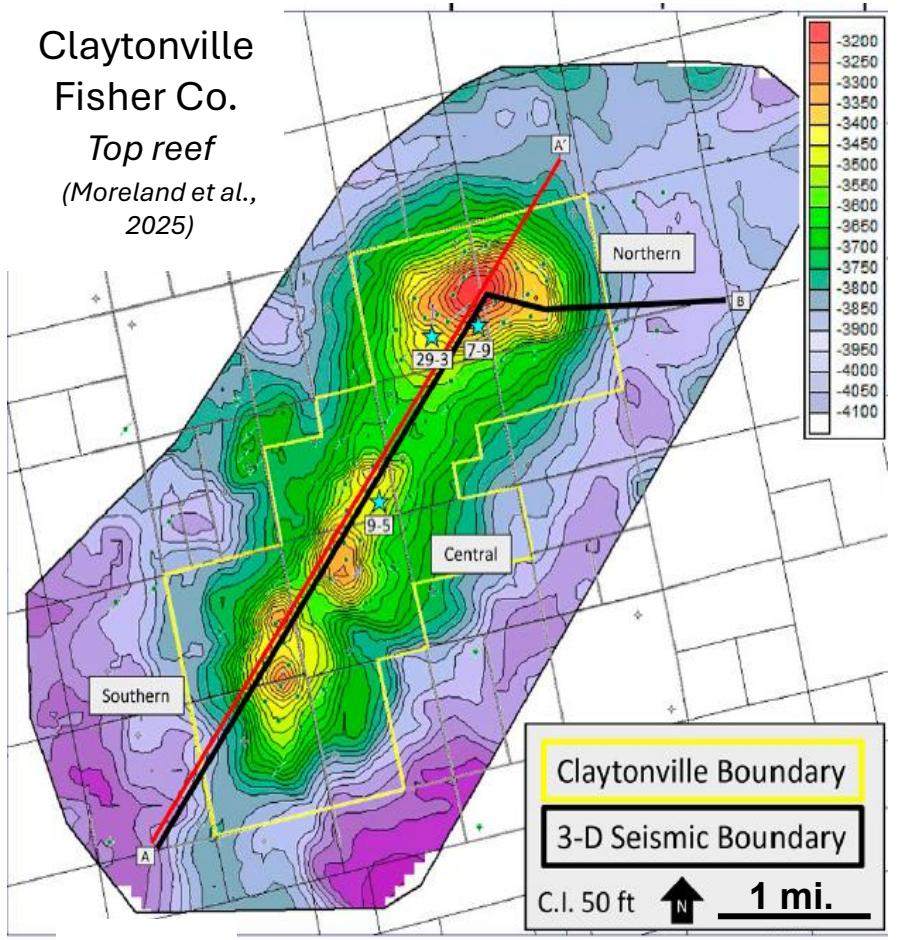
Millican
Coke Co. *(Zemkowski 1985)*
Top reef



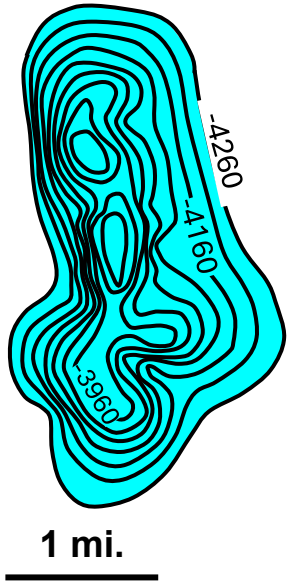
Jameson
Coke Co.
Top reef
(Whitton, 1949)



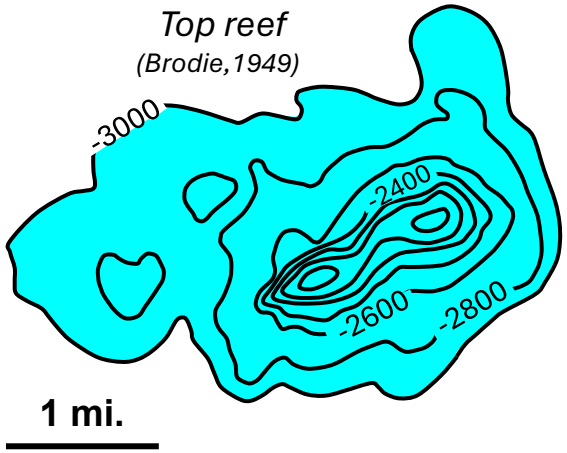
Claytonville
Fisher Co.
Top reef
(Moreland et al., 2025)



Ocho Juan
Fisher Co.
Top reef
(Mohanlal, UTD, in progress)

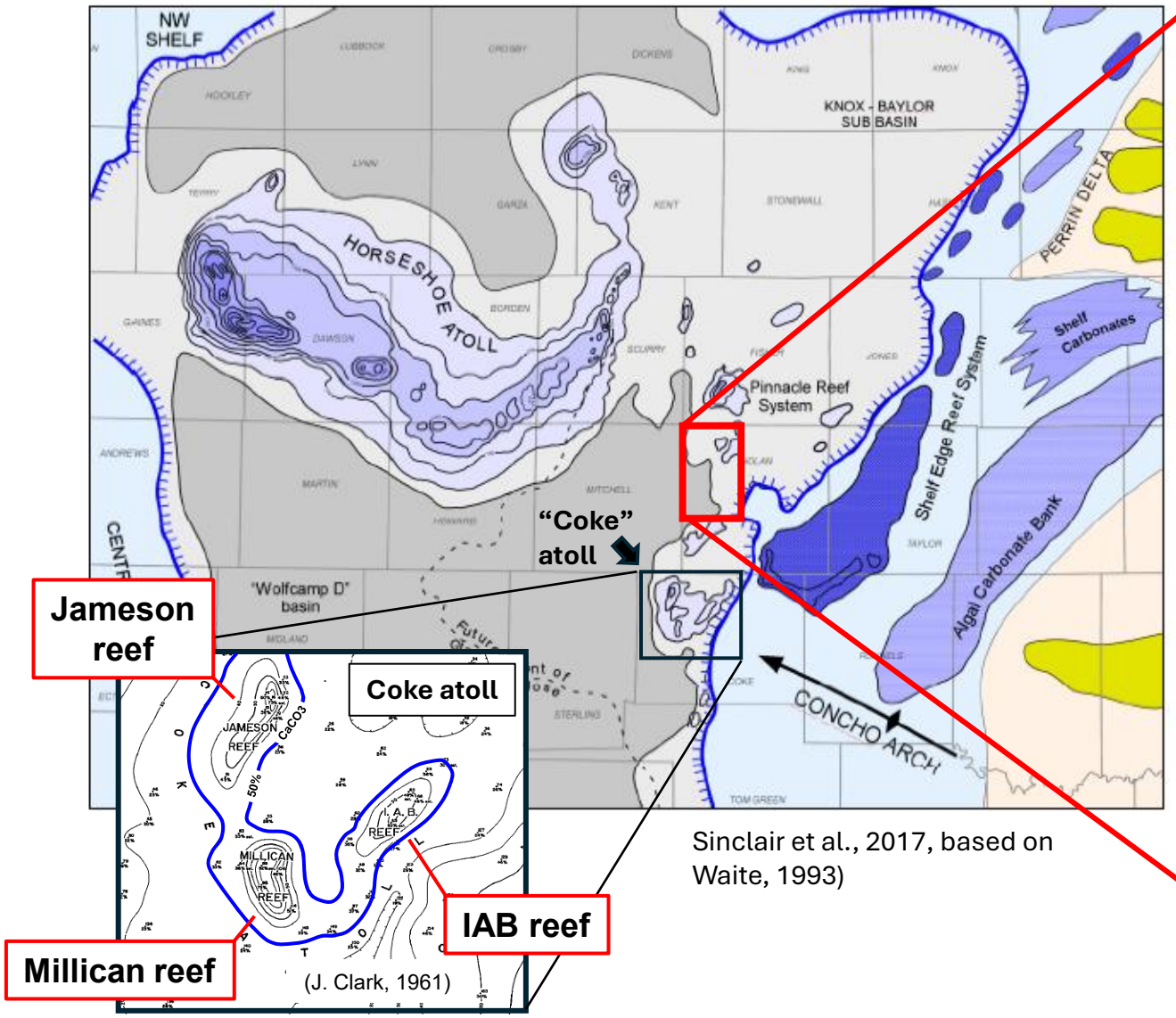


Round Top
Fisher Co.
Top reef
(Brodie,1949)

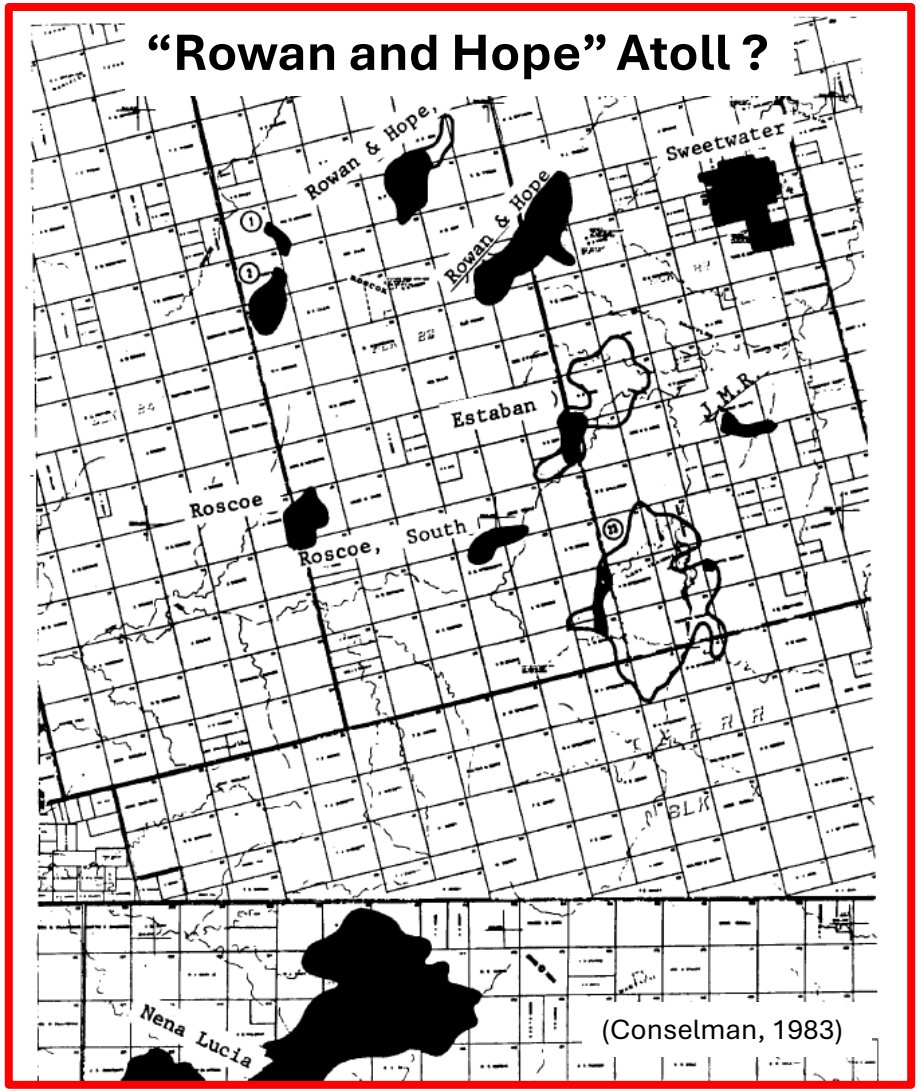


- Most ES reefs are elongate with a broad base and one or more high-standing pinnacles
- Dimensions: 1 – 2 miles wide, varying lengths (1- 7 miles)
- Dominant orientation: N – NE (facing into paleo trade winds)

“Mini” atolls ?



Sinclair et al., 2017, based on Waite, 1993)



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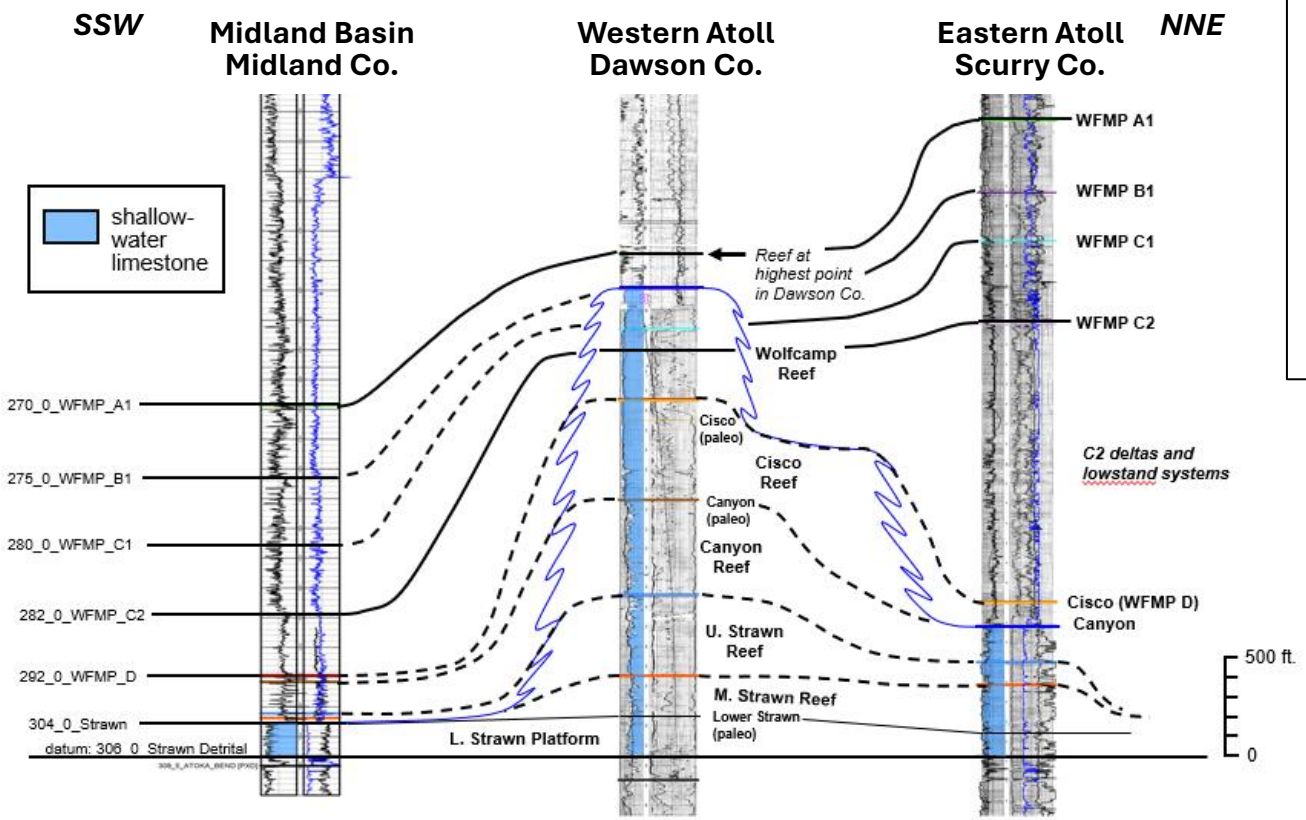
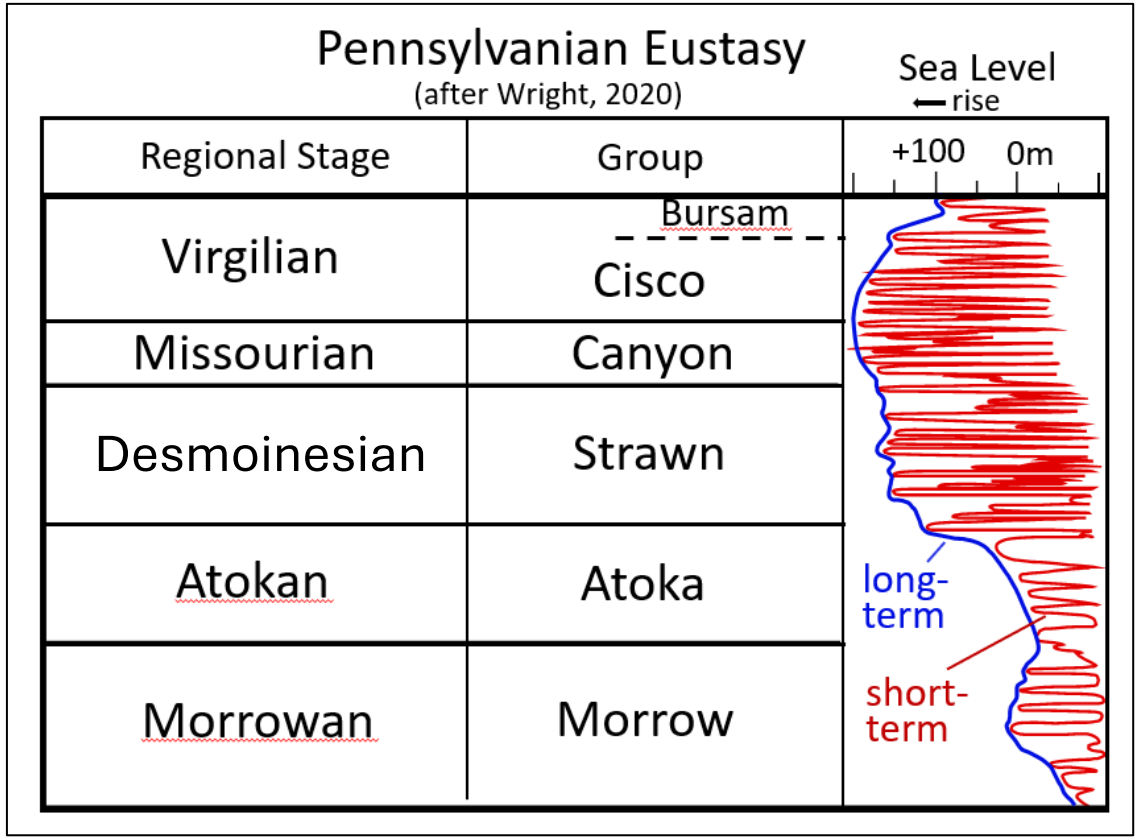
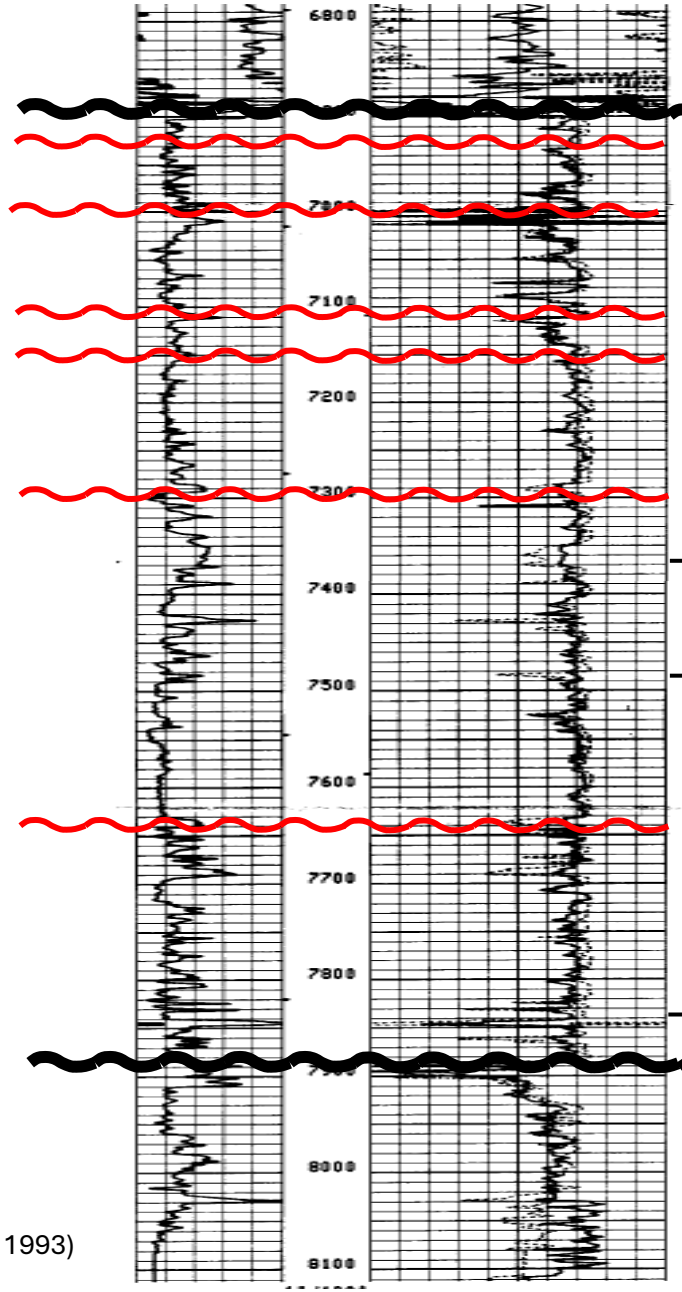
Pinnacle / “haystack” shape of Penn reefs is partially the result of subsidence during continued long-term rise in sea-level throughout Desmoinesian (Strawn) time





Reef geometry was also highly modified by multiple periods of erosion / karsting during multiple, glacially-driven lowerings of sea-level

Mobil #1 T.J. McDonnell
Scurry Co., Texas



early Wolfcamp

early Canyon

late Strawn

middle Strawn

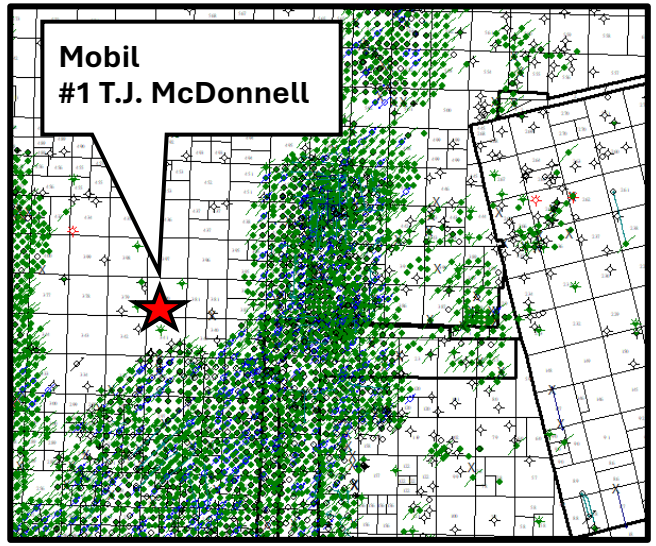
early Strawn

Miss.

Elbg.

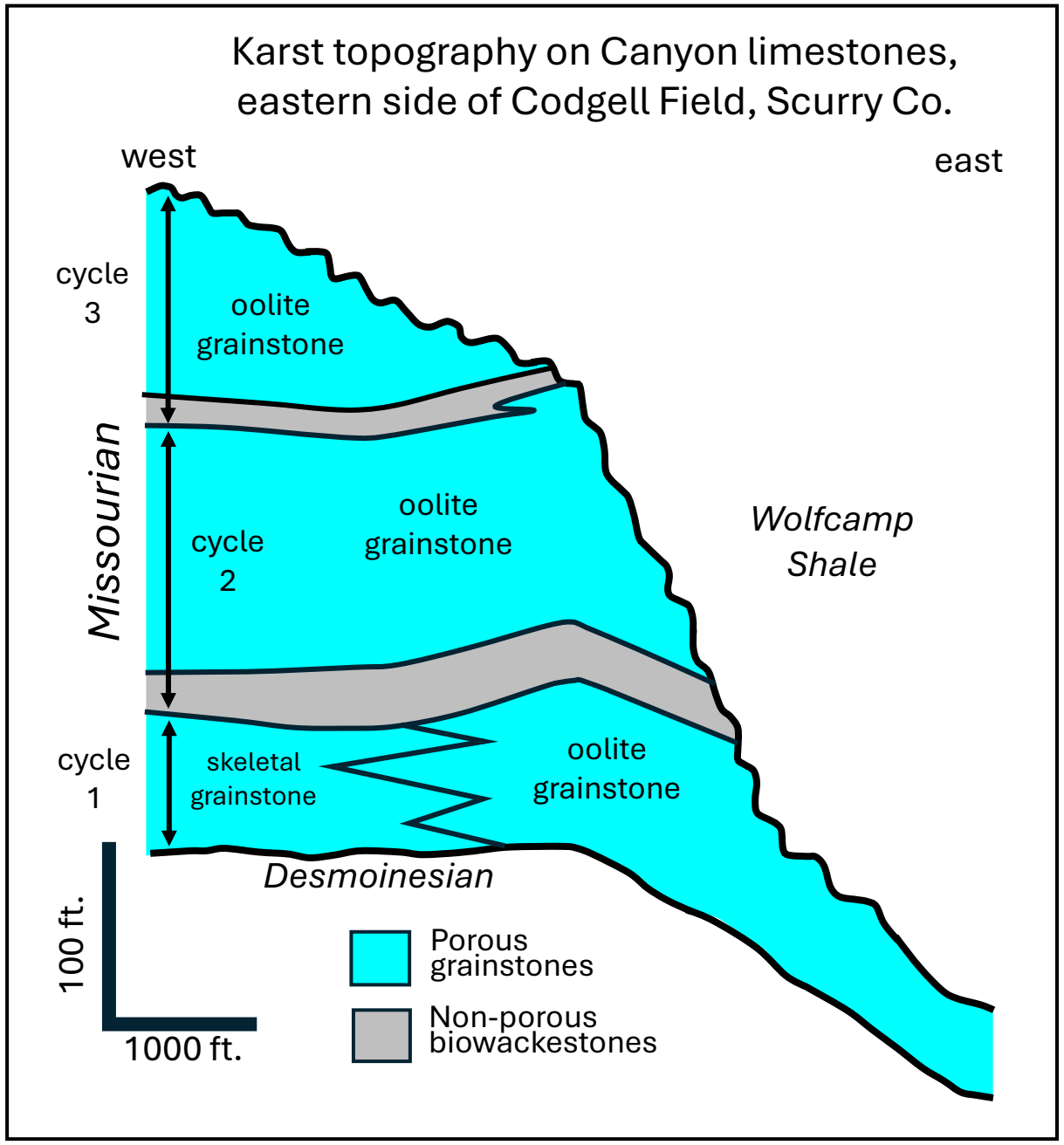
Exposure surface

(from Waite, 1993)

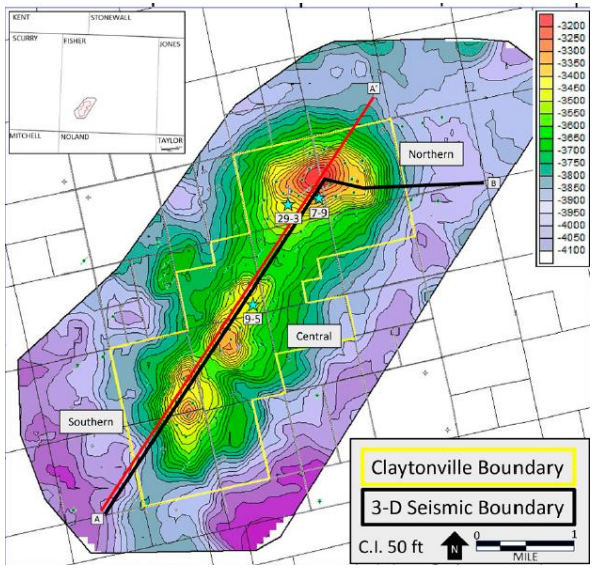


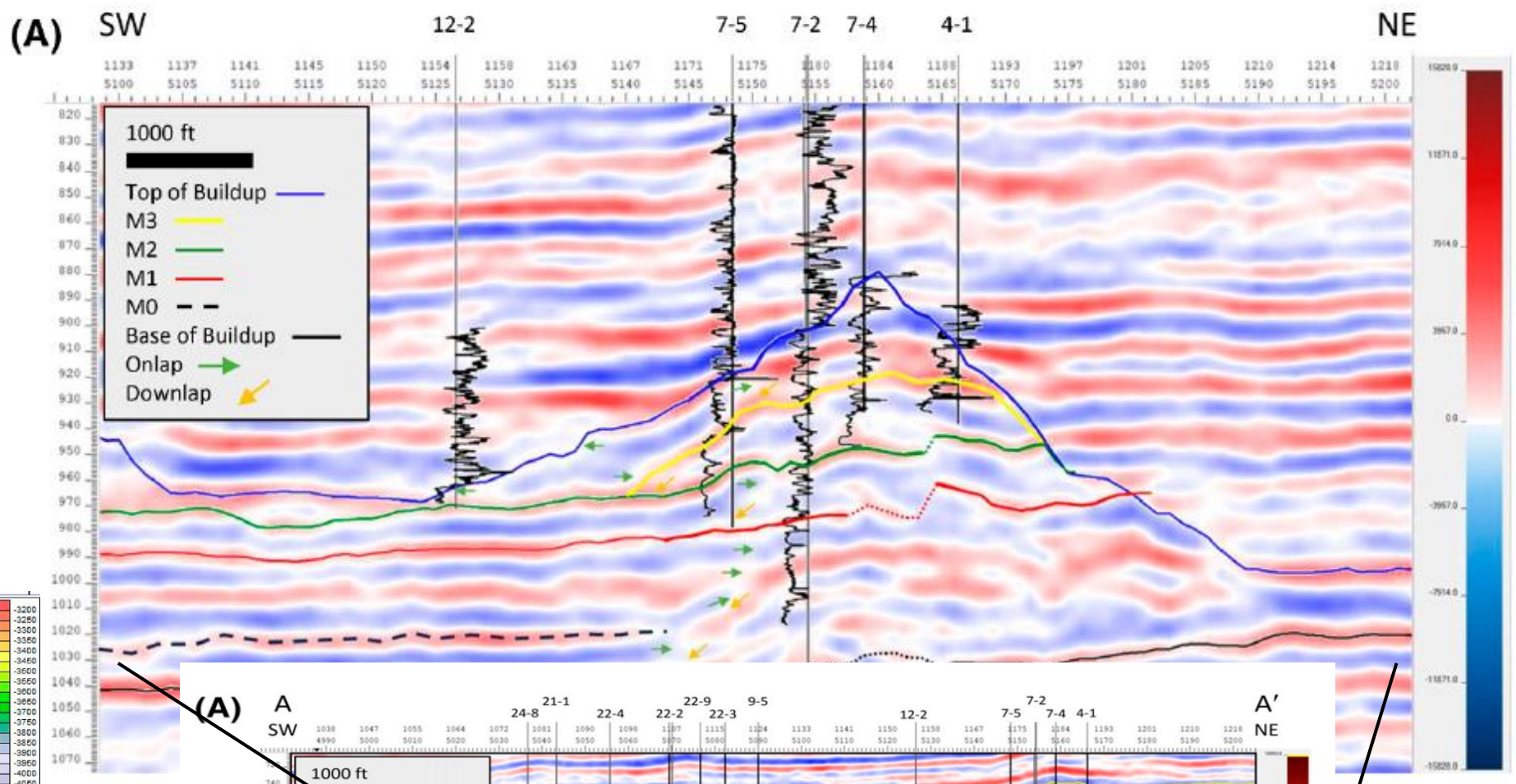
“Karsted hill” concept

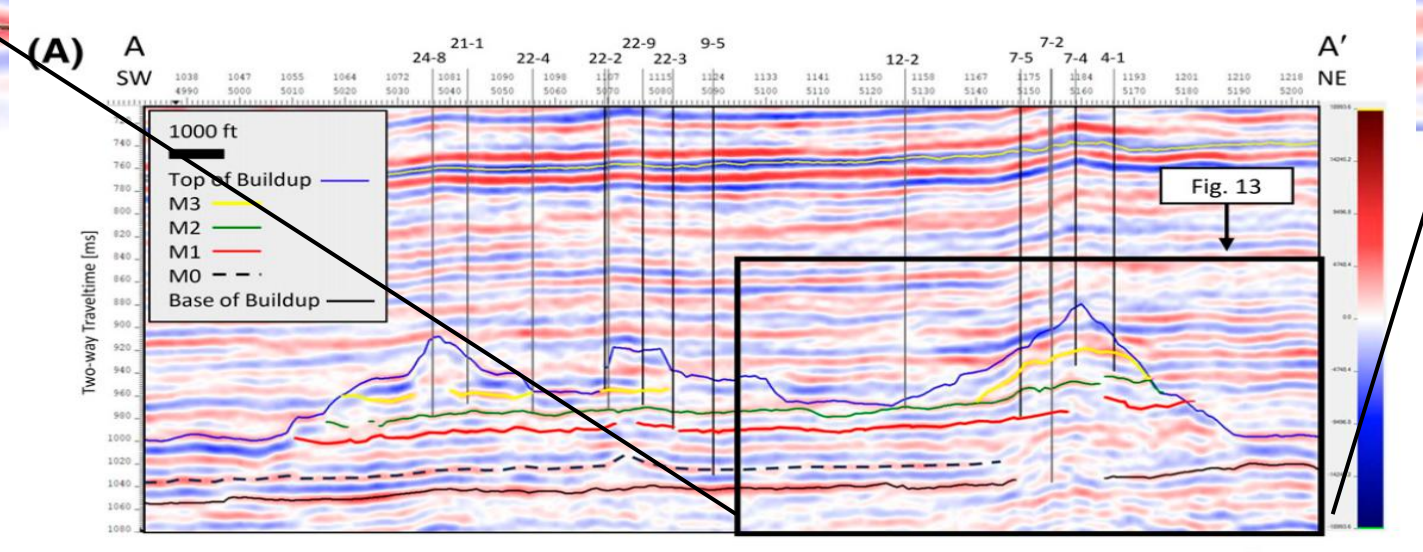
Mazzullo, 1997, after Reid and Reid, 1991)



A “karsted hill” on the Claytonville buildup



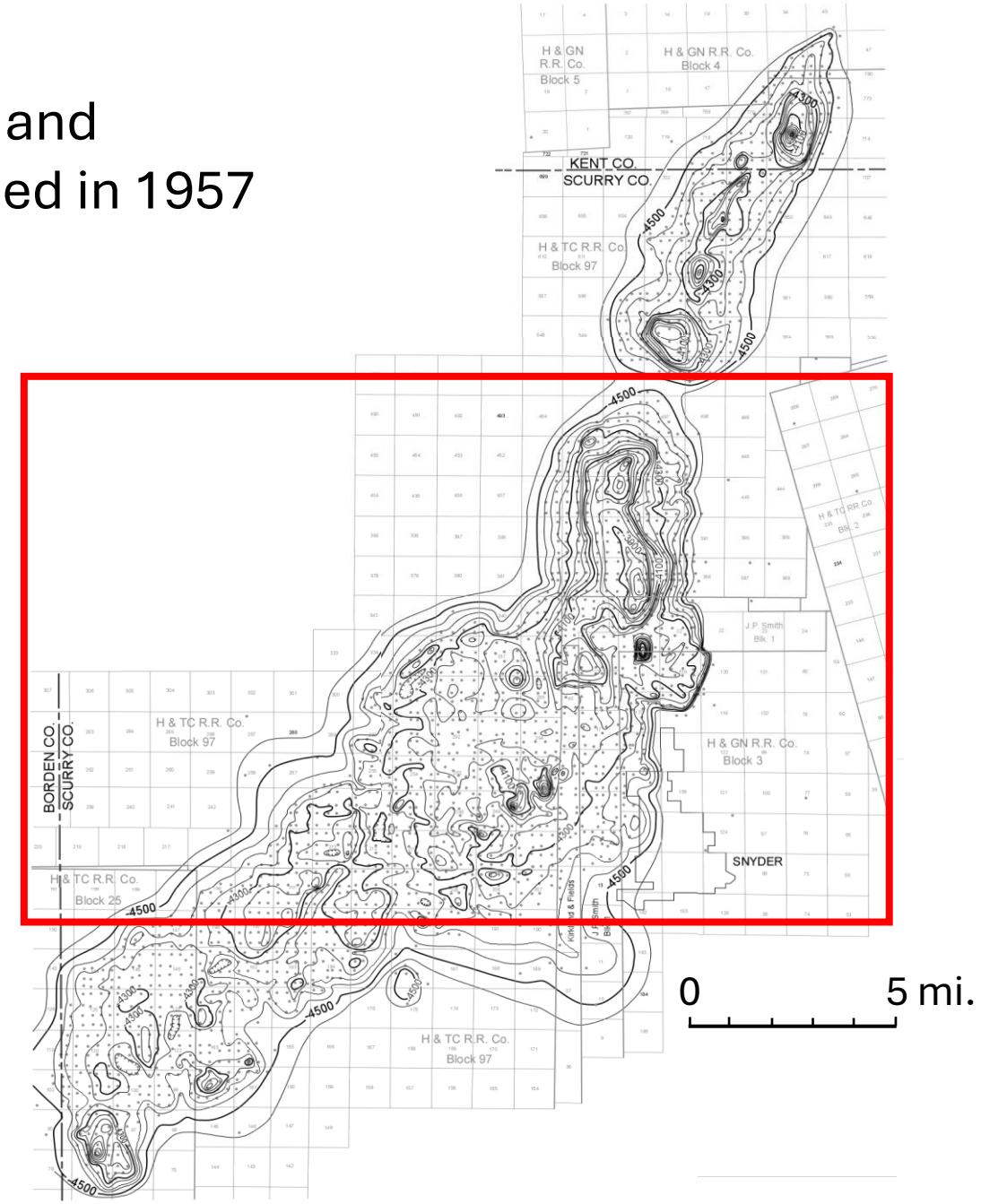




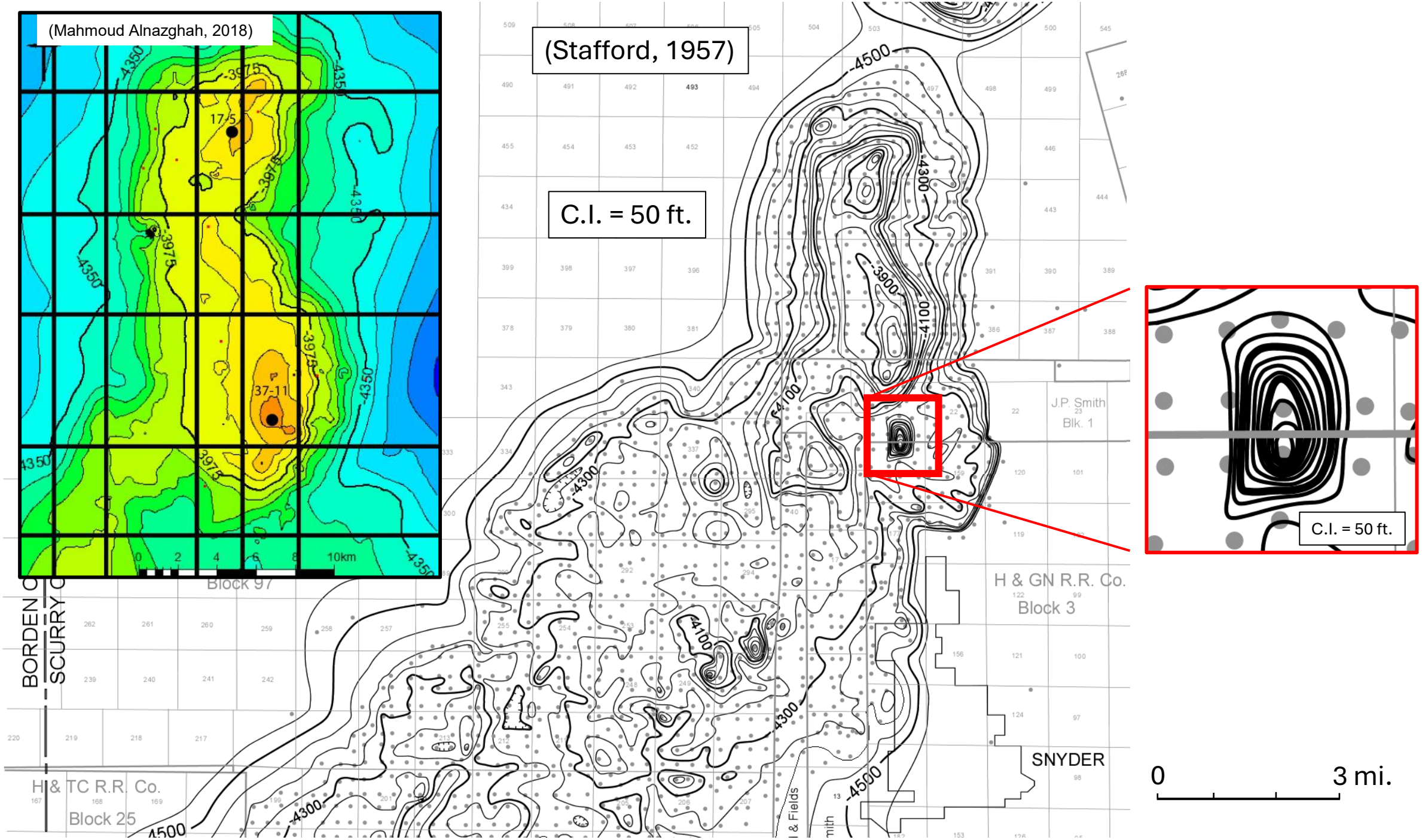
Structure map of Kelly-Snyder (Scurry) and Cogdell reefs published in 1957

(Stafford, “Scurry Field” in Occurrence of Oil and Gas in West Texas, Univ. of Texas – BEG Publication No. 5716, August, 1957)

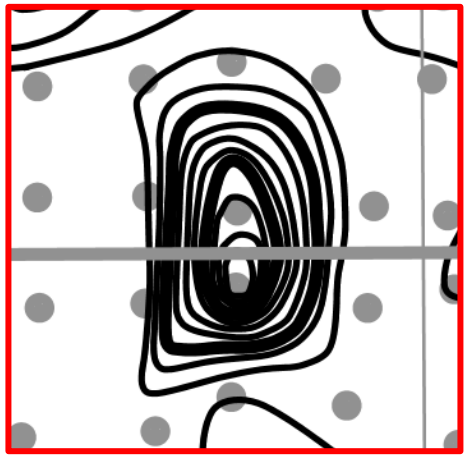
Contour interval = 50 ft.



- Detailed structural configuration of reefs was defined less than a decade after initial oil discovery
- Well control (~ 40 ac. spacing) shows complex topographical pattern along the margins and interior of the reef complex, with numerous indentations, closed highs, and lows


(Mahmoud Alnazghah, 2018)
(Stafford, 1957)
C.I. = 50 ft.
17-5
37-11
-4350
-3975
-4500
-4300
-4100
-3900
-4400
0 2 4 6 8 10km
C.I. = 50 ft.
J.P. Smith
Blk. 1
H & GN R.R. Co.
Block 3
SNYDER
Block 97
H & TC R.R. Co.
Block 25
BORDEN C
SCURRY C
0
3 mi.

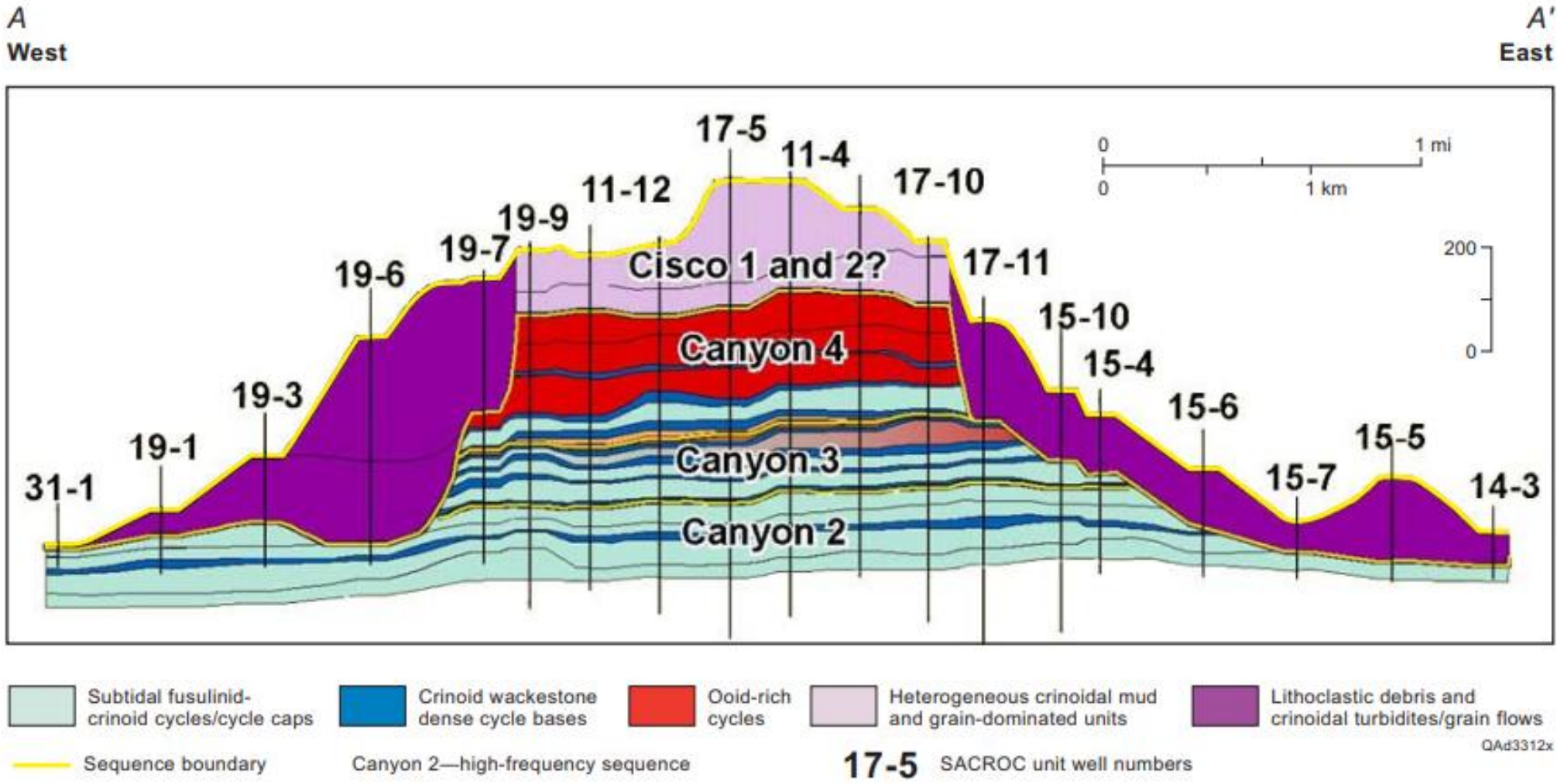

Tower karst, southern China
https://science-junkie.tumblr.com/



-4500
-4300
-4100
-3900
BORDEN CO.
SCURRY CO.
H & TC R.R. Co.
Block 97
H & TC R.R. Co.
Block 25
J.P. Smith
Blk. 1
H & GN R.R. Co.
Block 3
SNYDER
0
3 mi.

East – West cross section, SACROC reef, Scurry County (Dutton et al., 2004)

- Multiple periods of growth & erosion results in amalgamation of eroded debris on flanks of buildups
- Flow units in reef interior do not extend to flanks



Pennsylvanian reefs of the Eastern Shelf: Summary

What do we *really* know about Penn reefs of the Eastern Shelf?

- A lot
  - Distribution, sizes, and orientations
  - Internal complexity (yes, they are “reefs,” but…)
  - Role of long-term sea-level rise vs. multiple periods of erosion on defining final “pinnacle” shape
- Upon further review: We have much to learn
  - Many lack 3D seismic coverage required to assess internal reef geometry
  - Absence of deep, modern log suites hinders accurate detailed characterization
  - Efficiently draining these beasts and locating new reserves requires rigorous, geologic / reservoir models integrating log, 3D seismic, core, and production data

Many other topics to consider and discuss…

- Microfacies
- Fusulinid biostratigraphy
- Porosity types and distribution
- Permeability: lowstand vs. highstand units
- Production trends (decline curves, cumulative oil-gas-water, etc.)
- Relationship of reefs to younger “Canyon” sands
- Role of stylolites and fractures
- Cement types
- Recognition of eroded debris in core
- Data mining of old publications

…just to name a few

Eastern Shelf Penn reef operators:

I’d love to hear from you

Email Lowell.waite@utdallas.edu
Website https://labs.utdallas.edu/permianbasinresearch/
(search: “Permian Basin Research Lab”