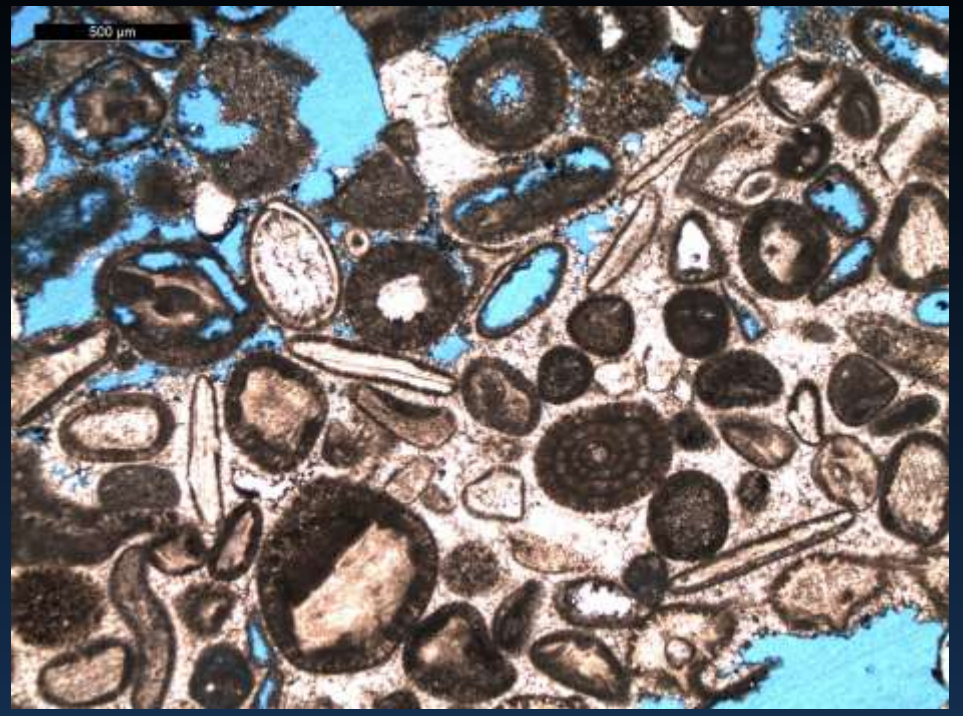
An Overview of the Strawn Group of Texas



Lowell Waite

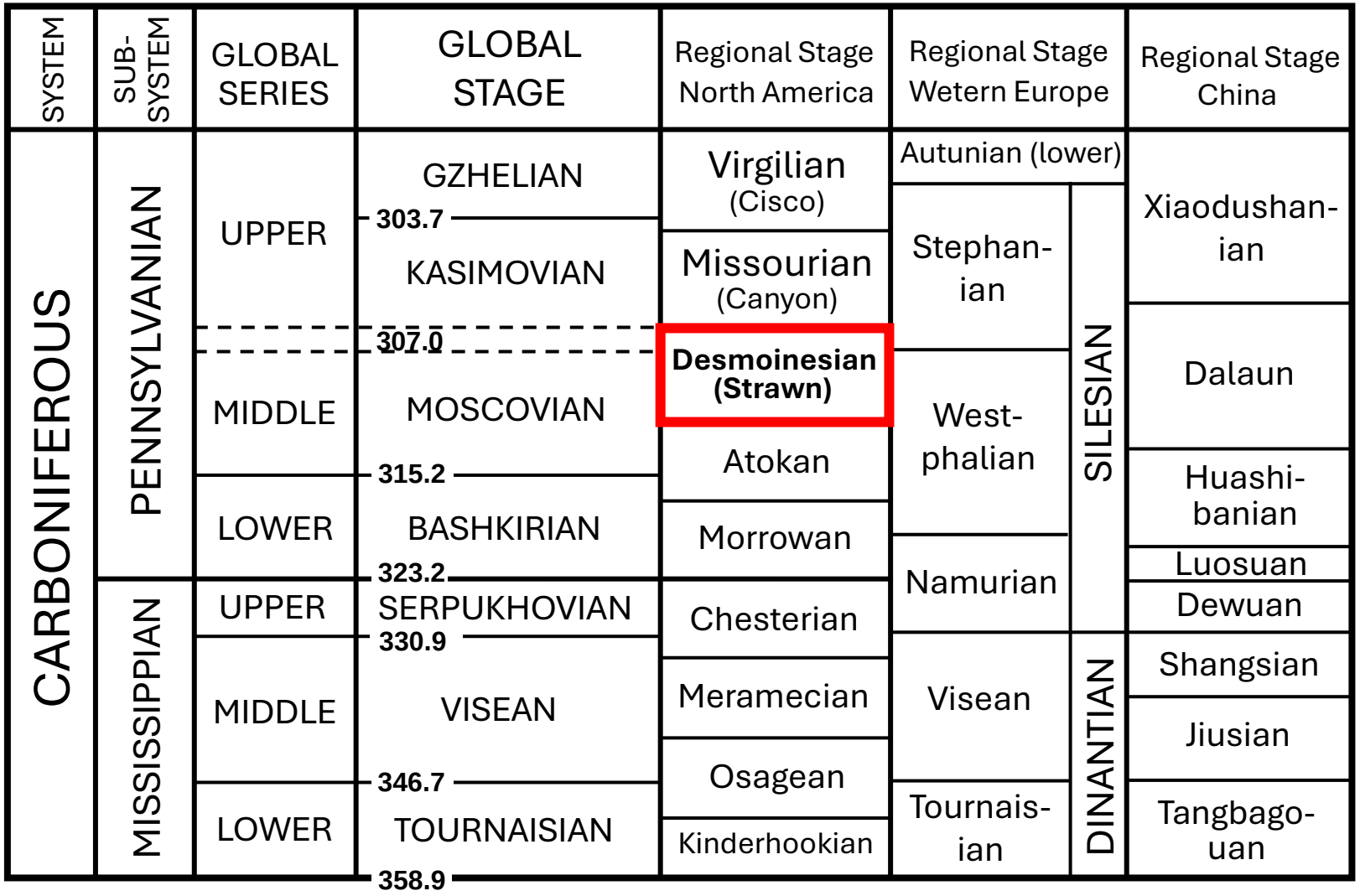
Co-Director, Permian Basin Research Lab
Dept. of Sustainable Earth Systems Sciences
University of Texas at Dallas

Dallas Geological Society
January 8, 2025

Strawn Group of Texas: Outline

- Introduction
  - Carboniferous time scale
  - Penn. global themes and regional geologic setting
  - Penn. sea-level changes
  - Strawn paleogeography
- Strawn Group stratigraphy
  - N. Central Texas outcrops
  - Subsurface
  - Fusulinid biozones of the Permian Basin
- Strawn petroleum system
- Strawn reefs of the Eastern Shelf
- Summary and conclusions

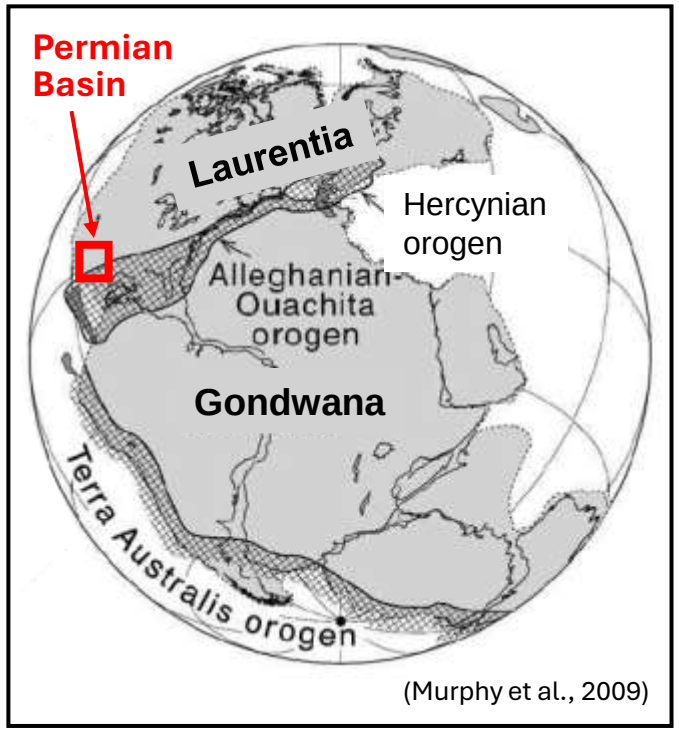
Carboniferous Time Scale



(modified from Heckel and Clayton, 2016 and Davydov et al., 2012)

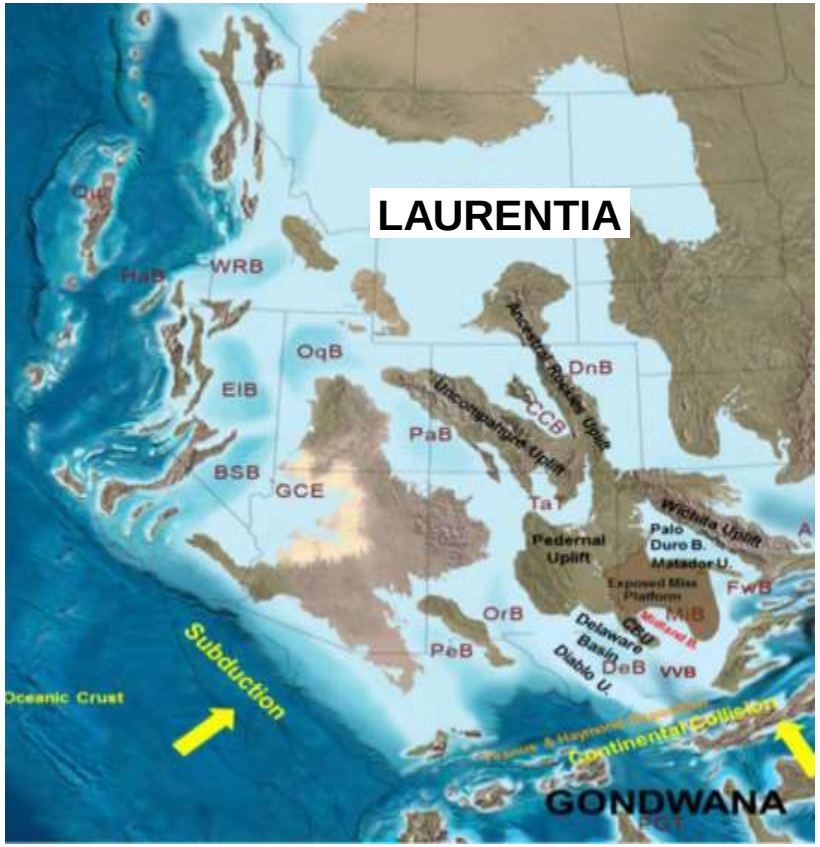
Pennsylvanian – Early Permian Global Themes

- SW Laurentian region during assembly of Pangea; active margin phase: Hercynian orogeny & rise of Ancestral Rockies (Tobosa Basin becomes Permian Basin)
- Climate: Icehouse phase throughout Penn. – Early Permian, transitioning to greenhouse; Permian Basin in low-latitudes (tropics); humid w/ monsoonal precipitation
- Sea level: long-term rise and expansion of Penn. seaway; short-term: **Penn cyclothems** (high frequency, high amplitude glacioeustatic cycles)
- Aragonite seas: dominance marine invertebrates with aragonite/high mag. calcite skeletons; limestones susceptible to early leaching)

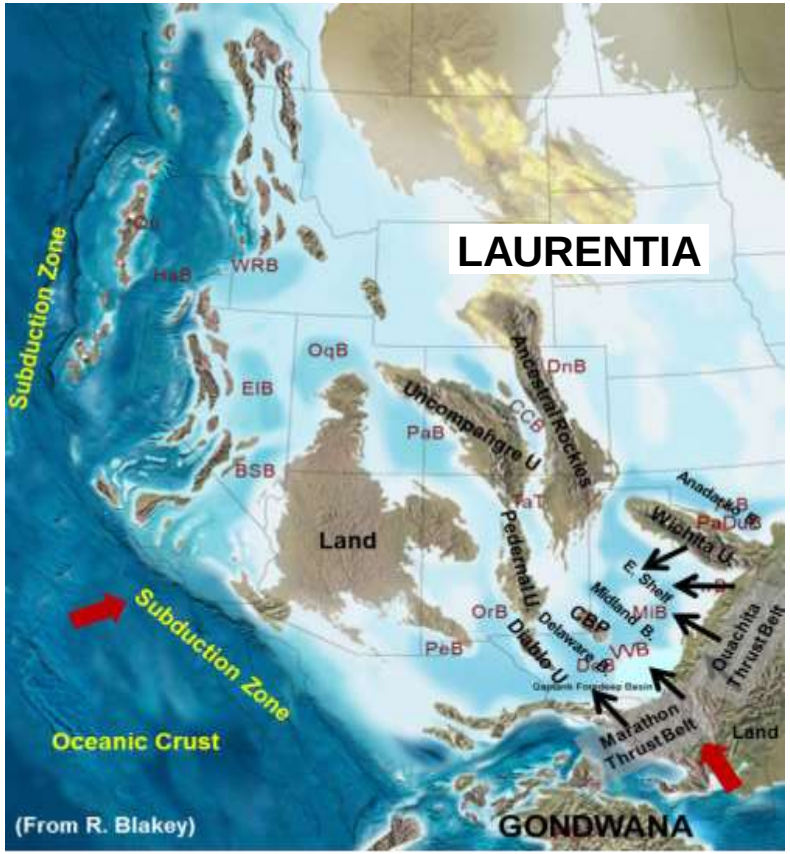


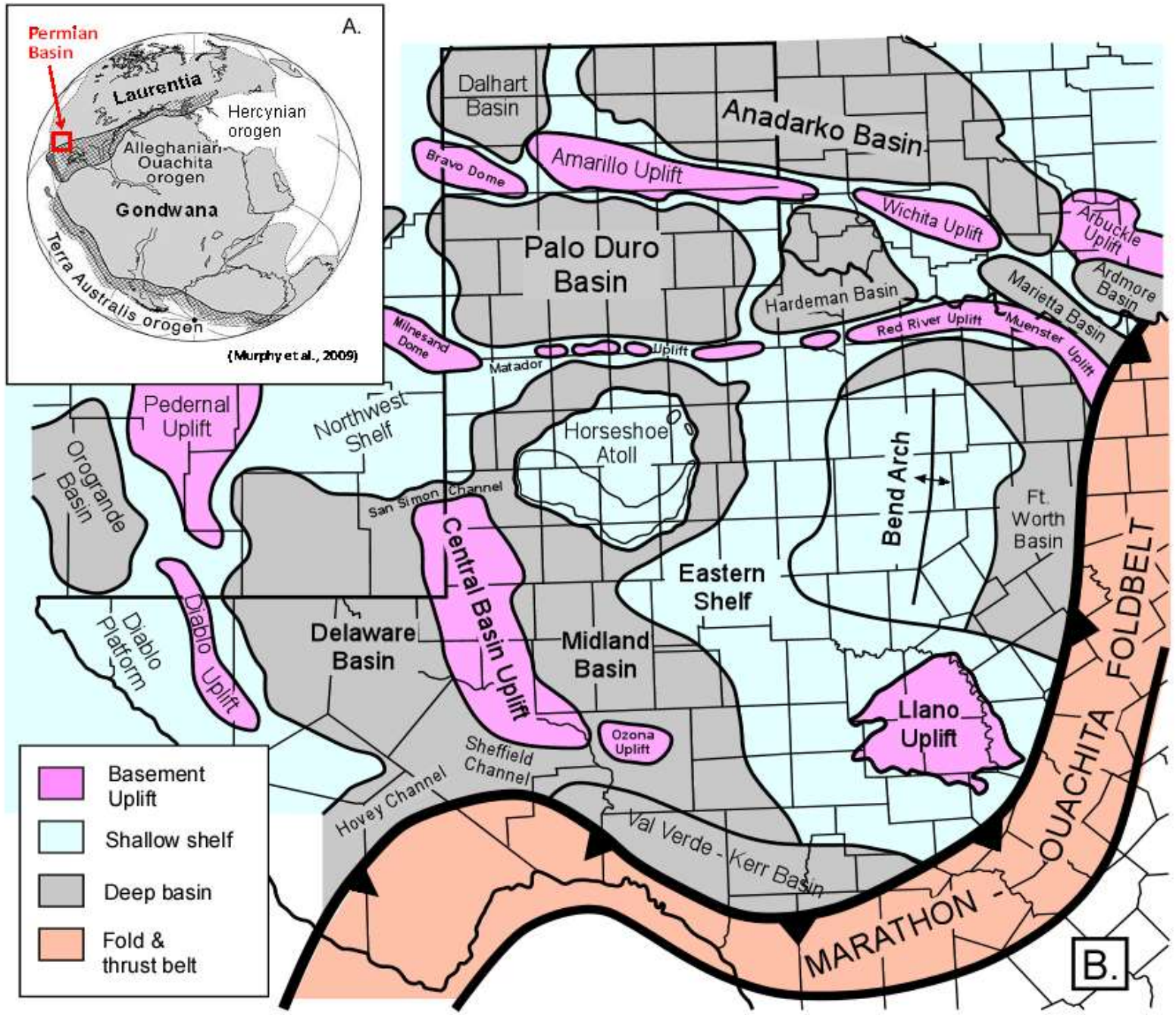
(Murphy et al., 2009)

Early Penn. (Atokan)



Late Penn. (Missourian)



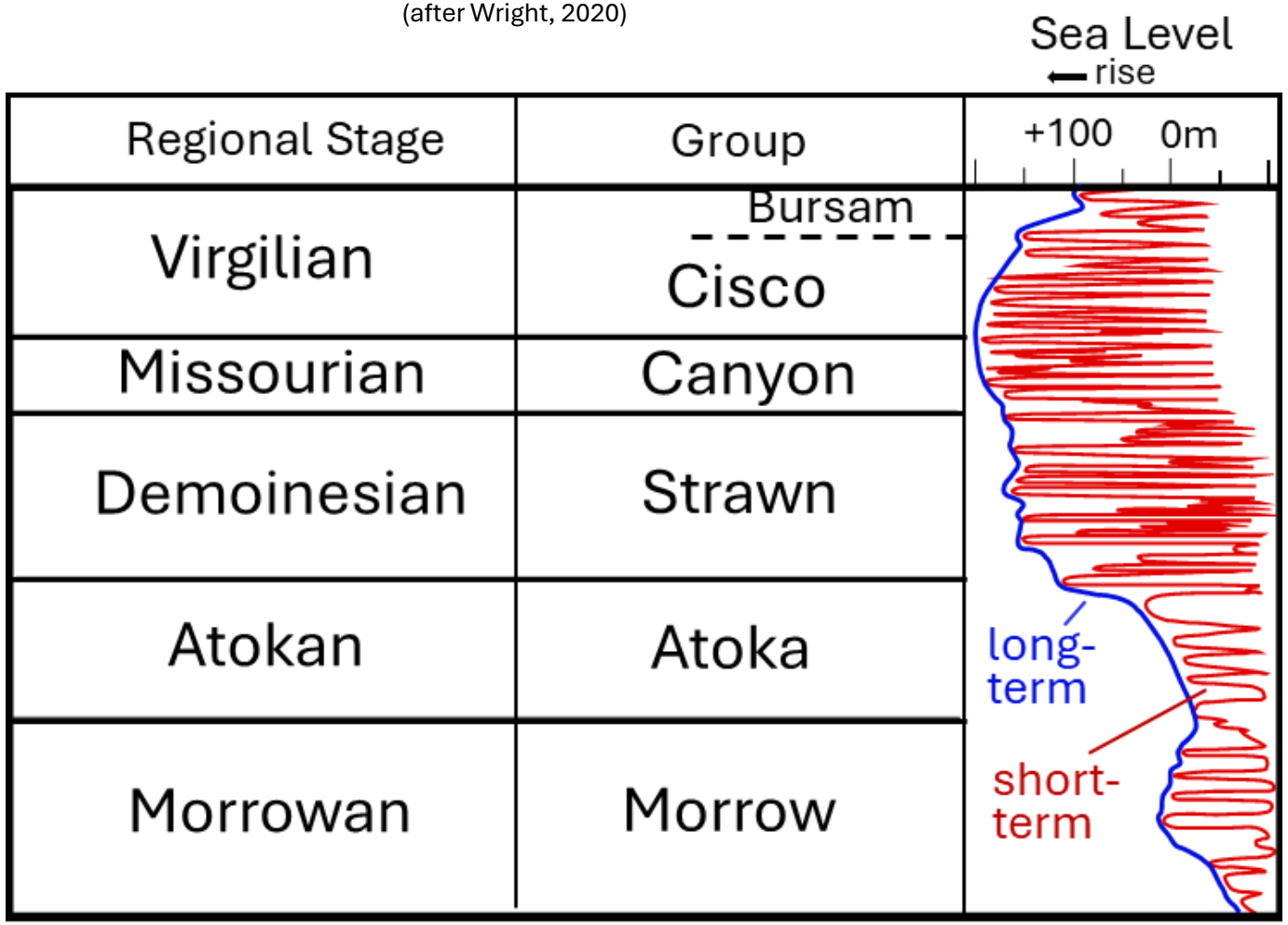


Regional Tectonic Setting of west Texas during the Late Carboniferous

- NW margin of assembling Pangea supercontinent
- Intersection of Hercynian Orogen (Marathon-Ouachita Fold Belt) and Ancestral Rockies System
  - Basement-involved fault-bounded uplifts
  - Adjacent deep basins
  - Surrounding shallow shelves
- Transition from passive margin (Tobosa Basin – Texas Arch) to active margin (Ft. Worth and Permian basins)

Pennsylvanian Eustasy

(after Wright, 2020)



Long-term sea-level (tectonic control)

- Prolonged transgression drowns the underlying L. Strawn Concho Platform and causes regional backstepping of shelves; time-equiv. organic-rich black shales (Wolfcamp D) deposited in rapidly subsiding “starved” basins

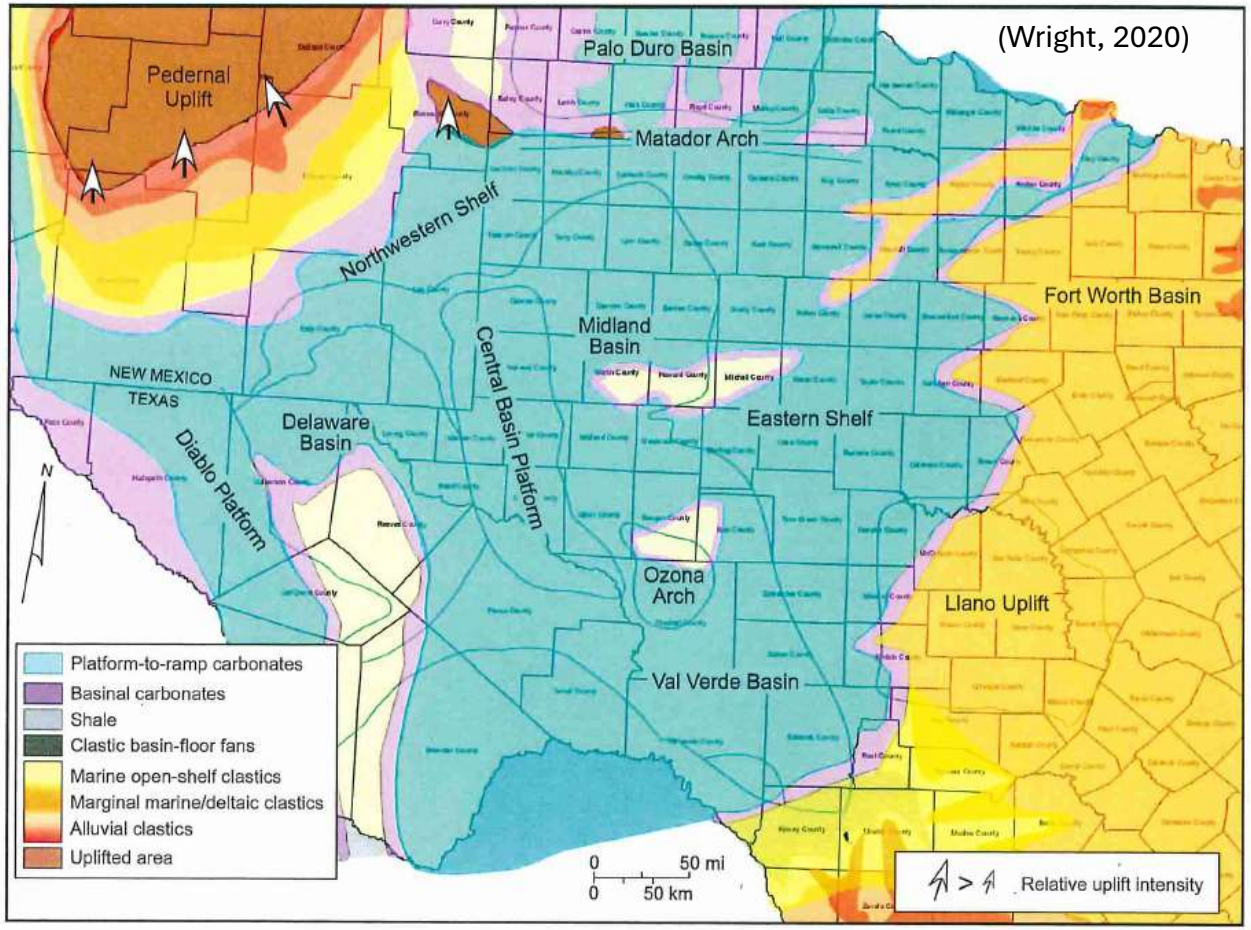
Short-term sea-level (glacioeustacy)

- During glacial maxima (S.L. lowstands), tectonically-active Ancestral Rockies uplifts and Ouachita Fold Belt shed voluminous amounts of clastics (channel/delta/slope systems) across Eastern Shelf
- During glacial minima (highstands), massive shallow-water carbonate deposition occurs along outboard shelf margins, including a series of large, isolated carbonate mounds/reefs

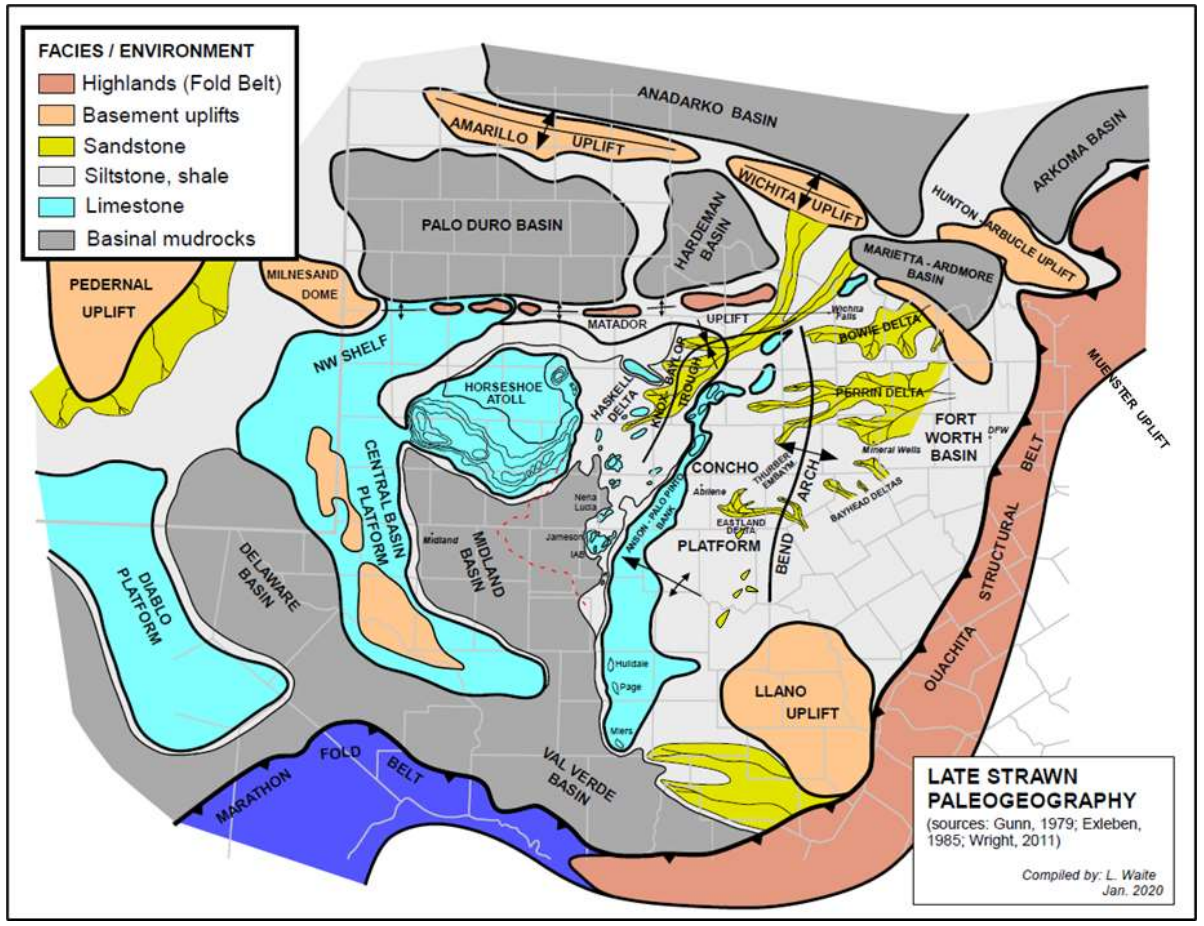
Strawn Paleogeography of Texas

1. Early Strawn
2. Middle & Upper Strawn

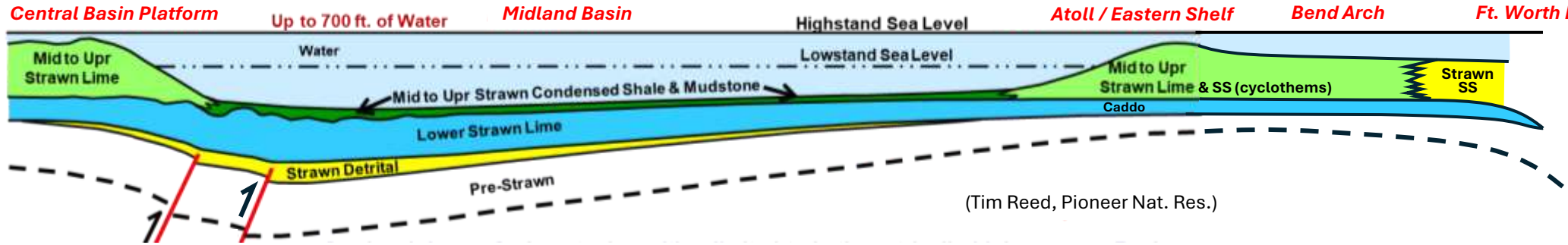
Early Desmoinesian (Early Strawn / Caddo)



Late Desmoinesian - Missourian (Upper Strawn - Canyon)



West — East



(Tim Reed, Pioneer Nat. Res.)

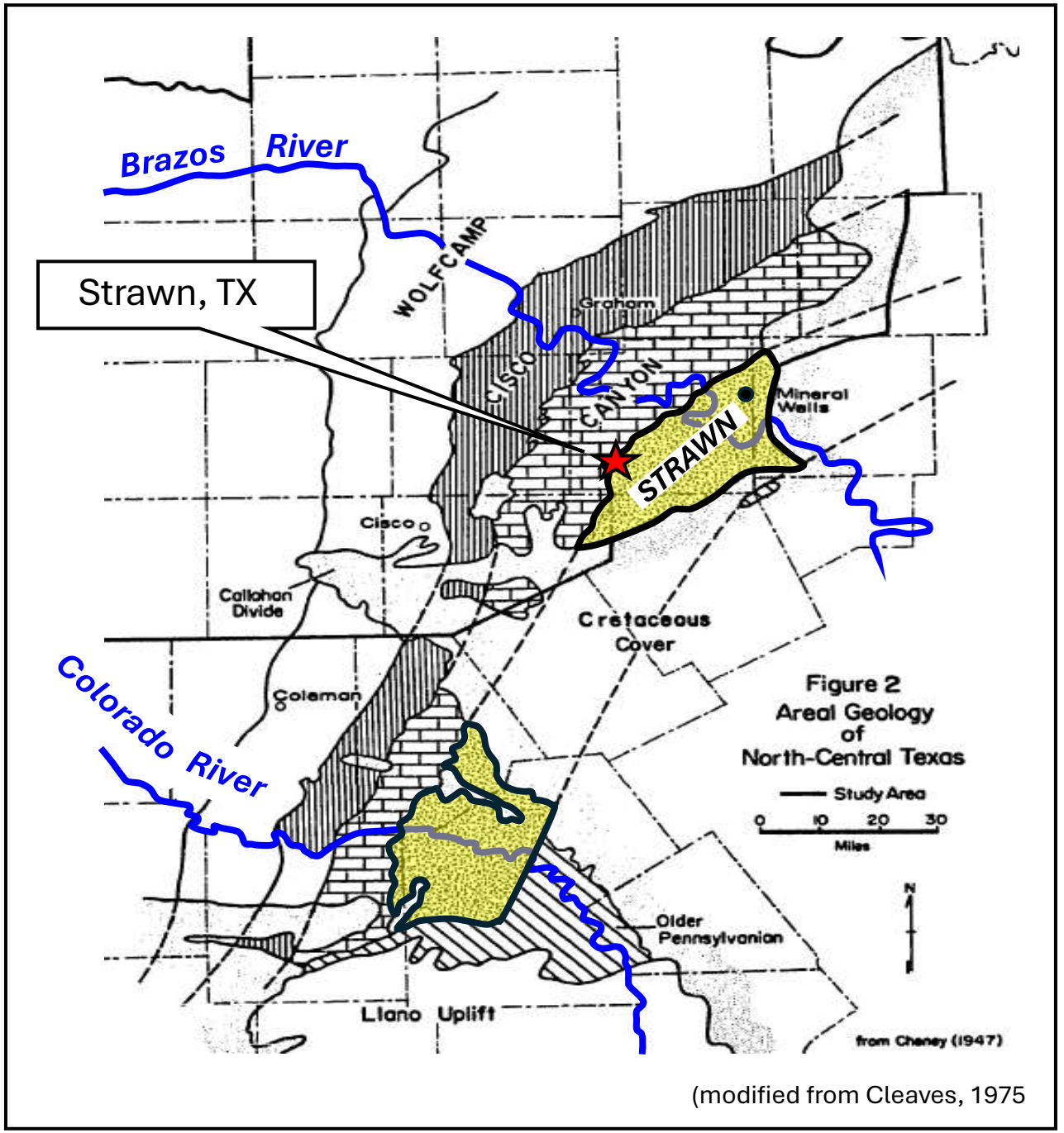
STRAWN STRATIGRAPHY OF TEXAS

1. Outcrop (North-Central Texas)
2. Subsurface

"Stratigraphy may be defined as the complete triumph of terminology over facts and common sense."

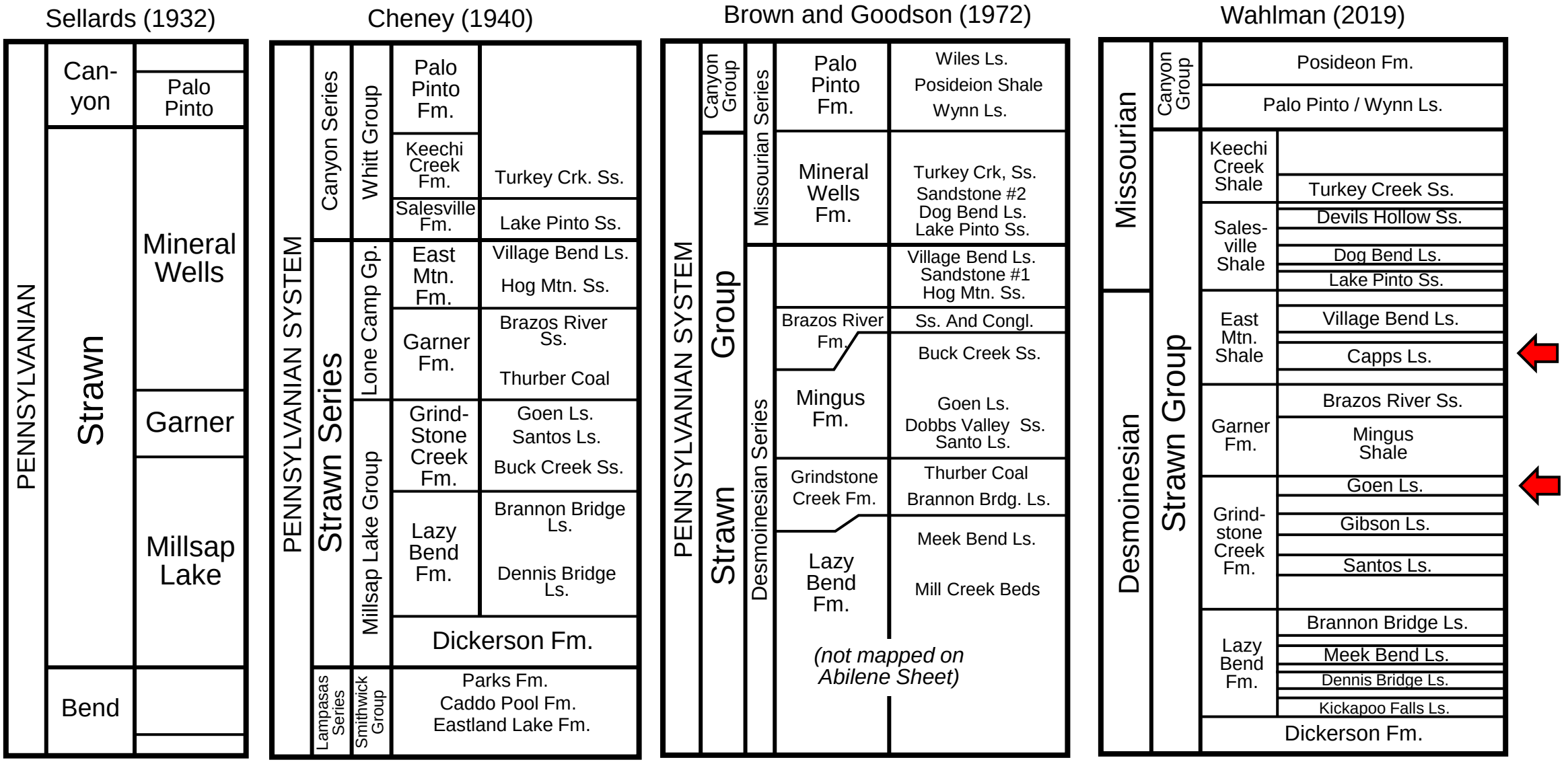
P. D. Krynine
Pennsylvania State University

Strawn outcrops,
N. Central Texas

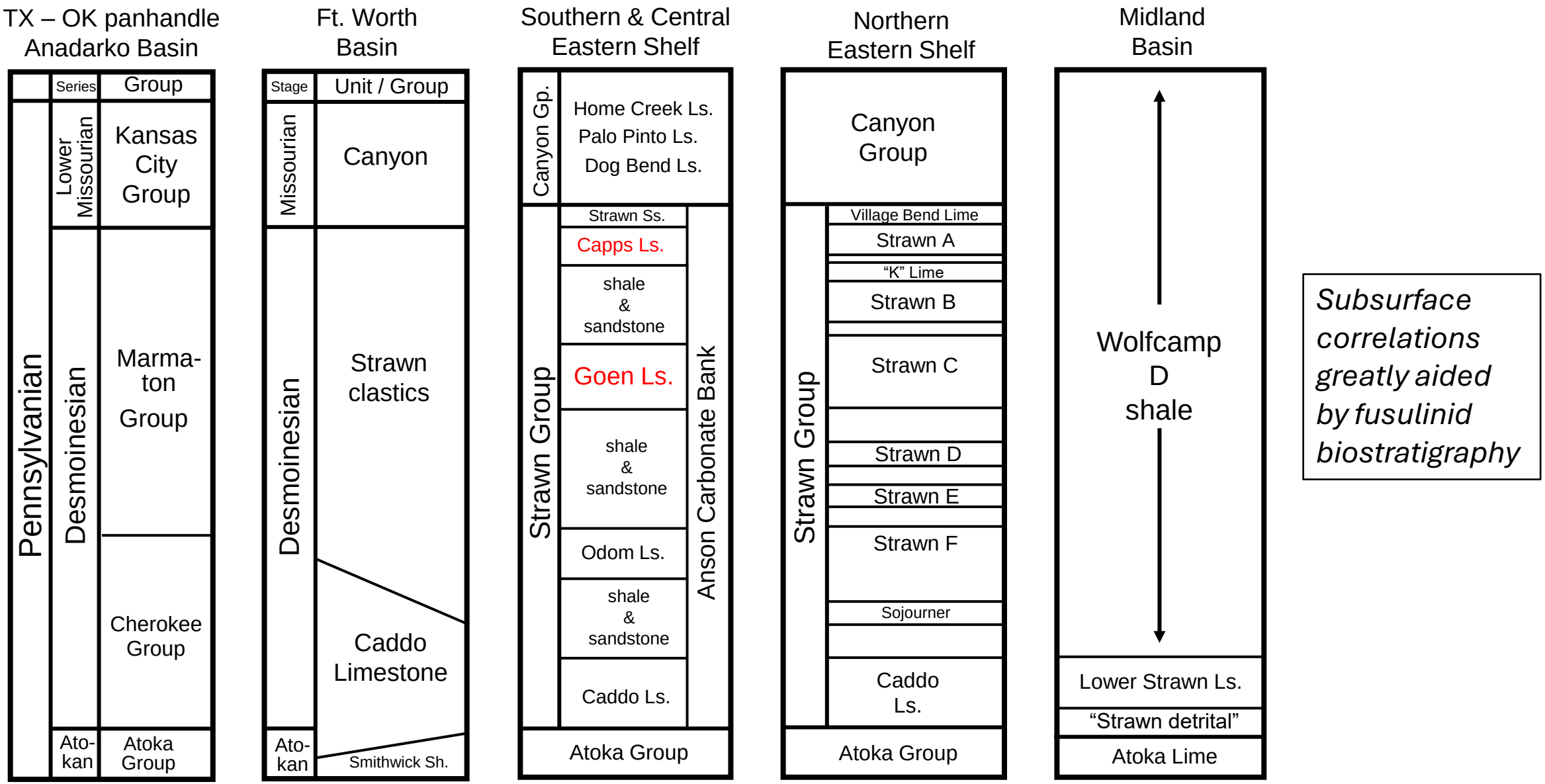


(modified from Cleaves, 1975

Evolution of Strawn Group terminology, N. Cen TX outcrops



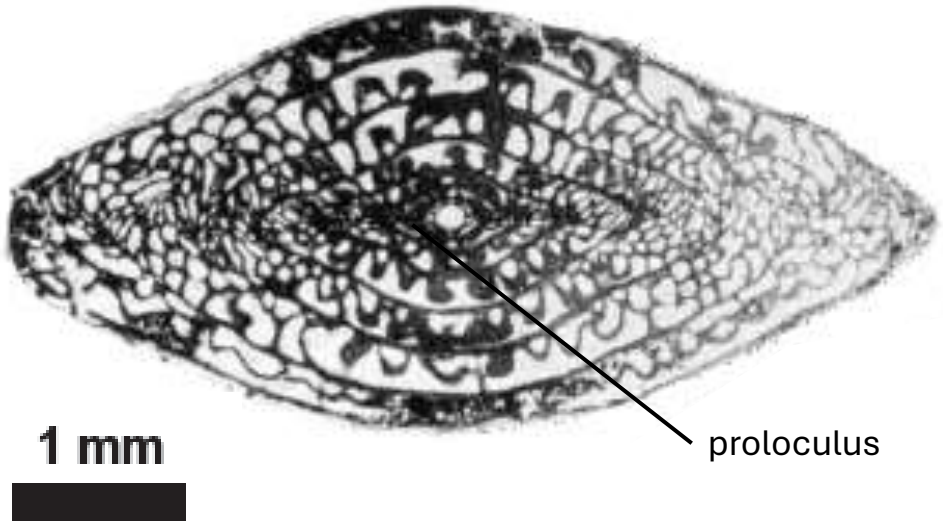
Strawn Group subsurface terminology: Varies by region

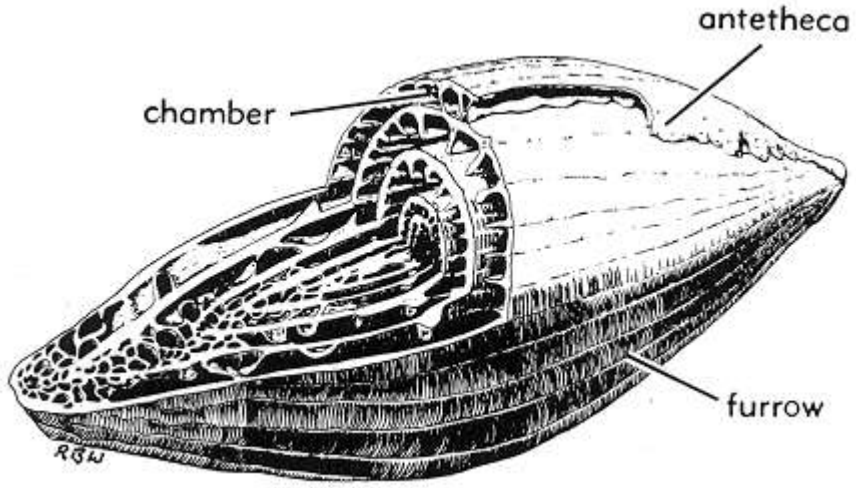


Subsurface correlations greatly aided by fusulinid biostratigraphy

Fusulinids

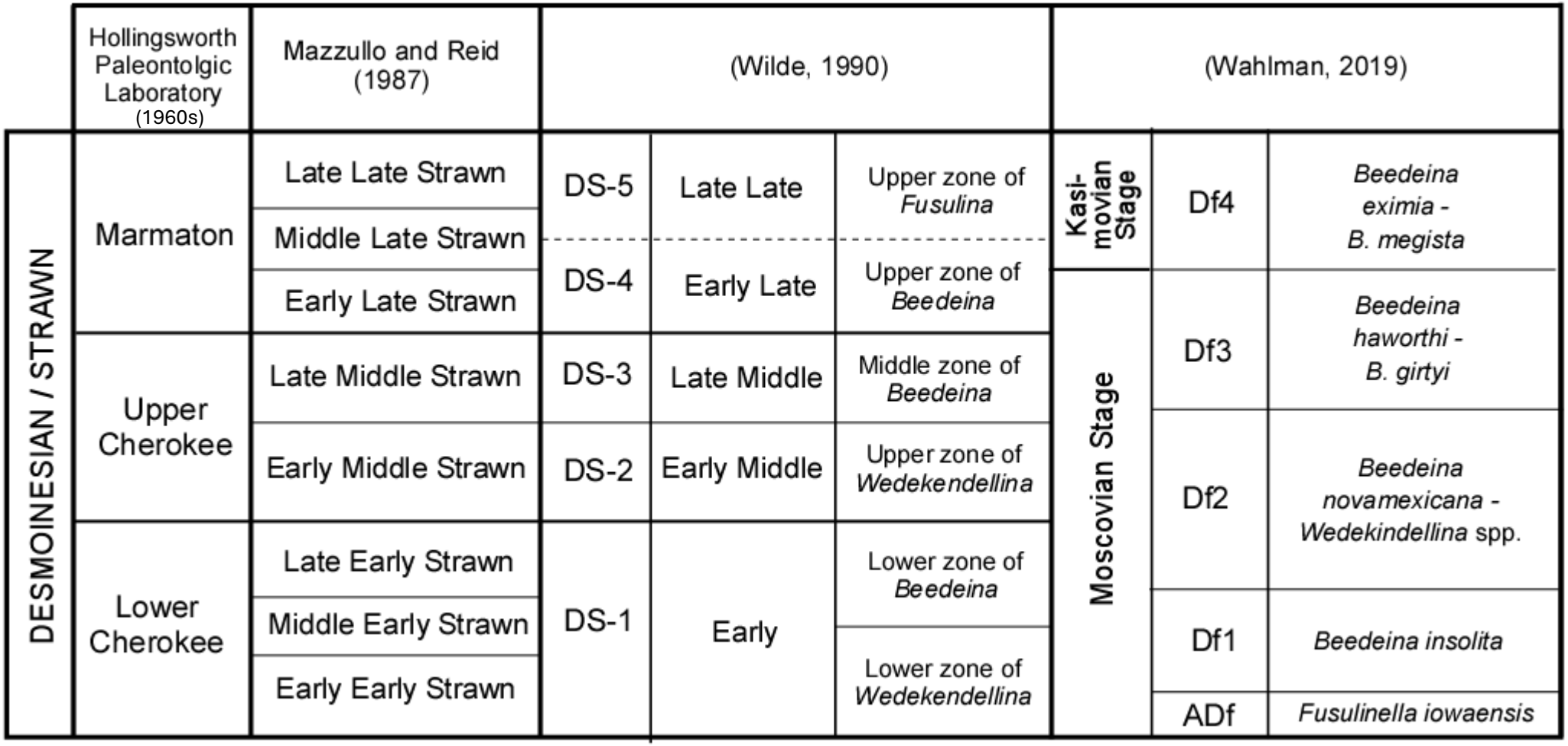
- A group of large, single-celled foraminifera that were common on Pennsylvanian - Permian carbonate shelves
- Rapid evolution, increasing in size and internal complexity throughout Penn – Perm time
- Size, shape, and distinct internal features provide basis for precise biozonation





(sources: Wikipedia; Wahlman, 2019)

Fusulinid zonations, Permian Basin

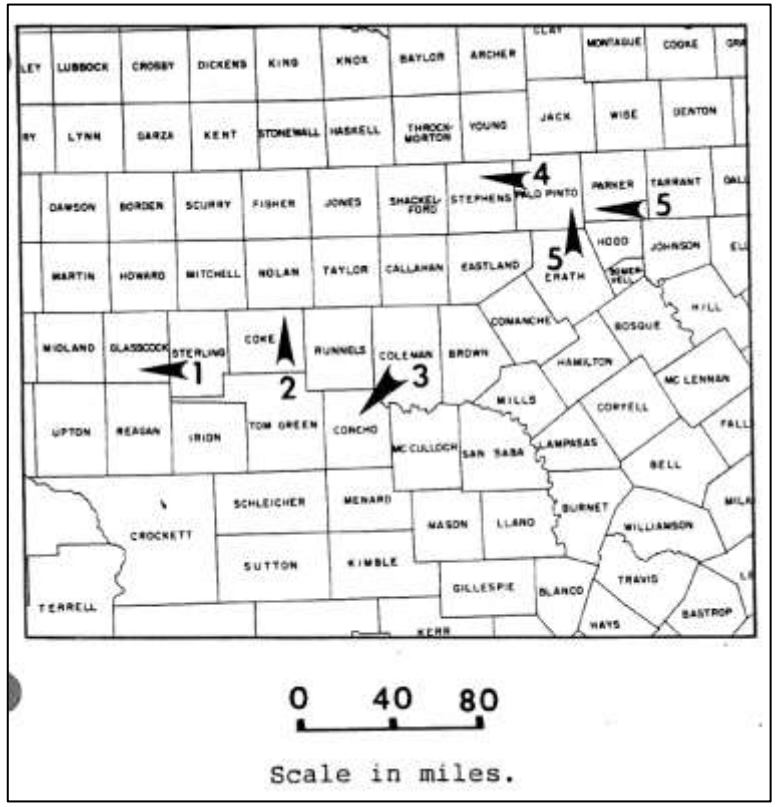


	Hollingsworth Paleontolgic Laboratory (1960s)	Mazzullo and Reid (1987)	(Wilde, 1990)			(Wahlman, 2019)		
DESMOINESIAN / STRAWN	Marmaton	Late Late Strawn	DS-5	Late Late	Upper zone of *Fusulina*	Kasimovian Stage	Df4	*Beedeina eximia - B. megista*
		Middle Late Strawn						
		Early Late Strawn	DS-4	Early Late	Upper zone of *Beedeina*	Moscovian Stage	Df3	*Beedeina haworthi - B. girtyi*
	Upper Cherokee	Late Middle Strawn	DS-3	Late Middle	Middle zone of *Beedeina*			
		Early Middle Strawn	DS-2	Early Middle	Upper zone of *Wedekendellina*		Df2	*Beedeina novamexicana - Wedekindellina* spp.
	Lower Cherokee	Late Early Strawn	DS-1	Early	Lower zone of *Beedeina*			
		Middle Early Strawn					Df1	*Beedeina insolita*
		Early Early Strawn			Lower zone of *Wedekendellina*		ADf	*Fusulinella iowaensis*

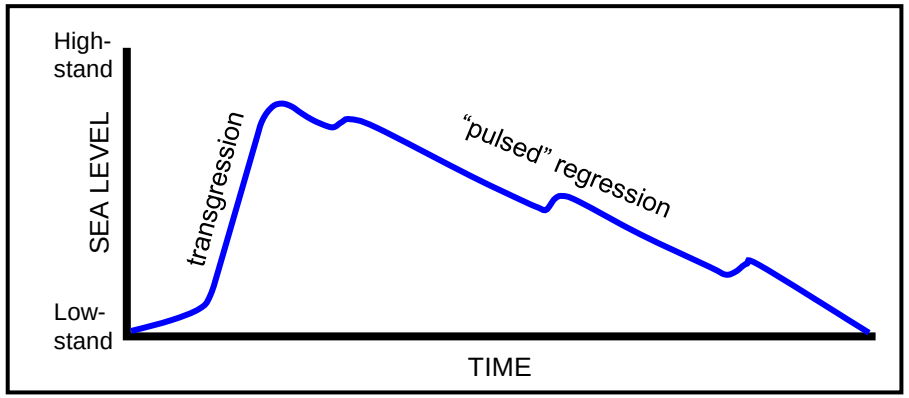
Strawn Biostratigraphy and Facies Mosaics: What is the Caddo?

Al Reid and S. J. Mazzullo
Geological Consultants
Midland, Texas

SOUTHWEST SECTION
OF AAPG
1987 Convention Transactions with Abstracts
DALLAS, TEXAS



Late Late Strawn Middle Late Strawn Early Late Strawn	Marmaton
Late Middle Strawn Early Middle Strawn	Upper Cherokee
Late Early Strawn Middle Early Strawn Early Early Strawn	Lower Cherokee



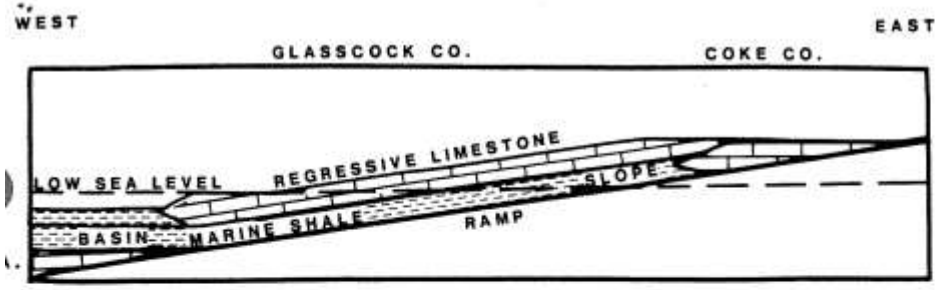


Figure 4A. Regressive marine limestone deposited during a slow sea level drop during the middle early Strawn time fusulinid zone. Note that the middle early Strawn seemingly can be correlated directly into the early early Strawn higher on the shelf. Basin subsidence prevented the middle early Strawn limestone from being deposited as far west as the early early Strawn lowstand carbonate.

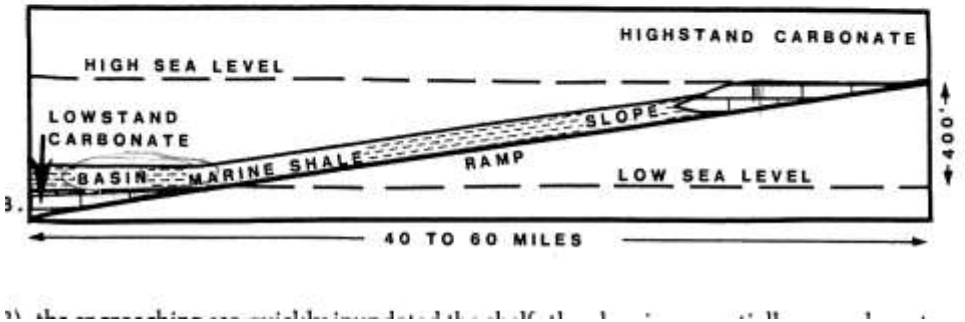
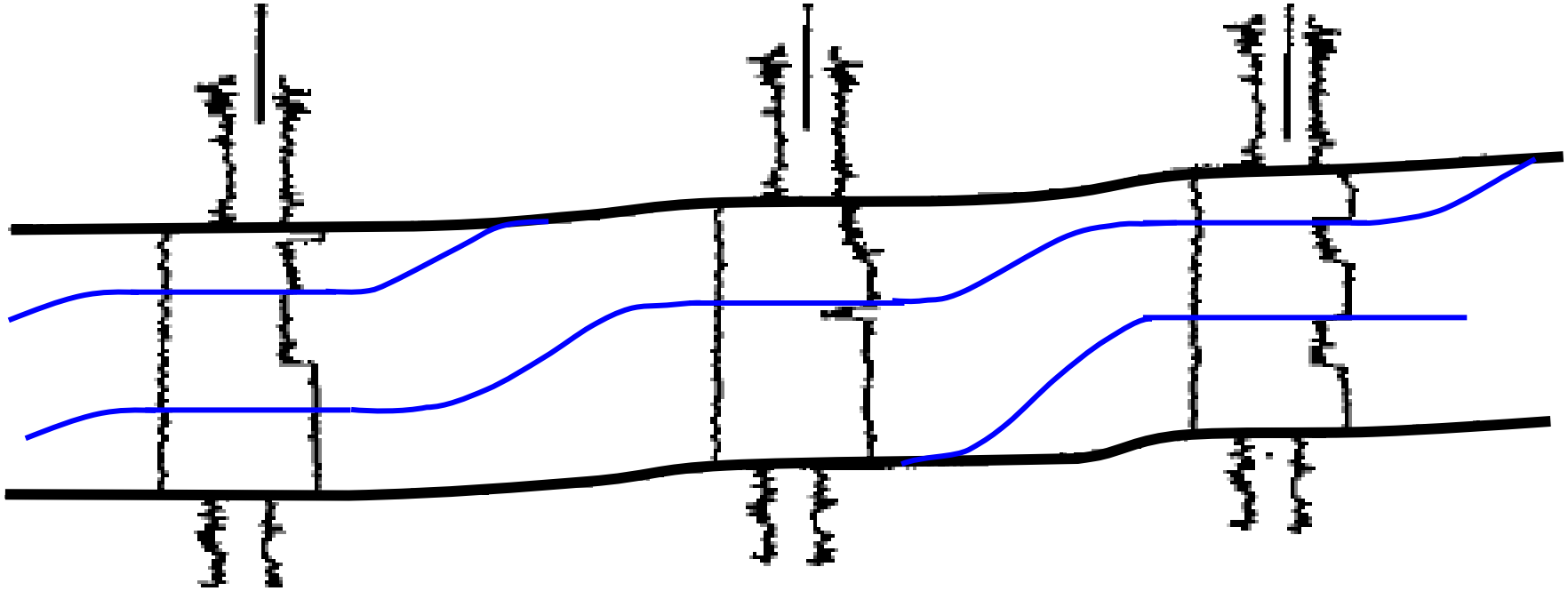


Figure 4B. Two carbonate units deposited during the same fusulinid time zone, (early early Strawn) during a sea level lowstand and during a subsequent sea level highstand. Note that no carbonate was deposited during the rapid transgression from the lowstand to the highstand, and that marine shale was deposited on the deep shelf ramp and over the lowstand carbonate during the sea level highstand. The highstand carbonate would be equivalent to the "Caddo" in the Suggs Ellenburger field.

Penn (Strawn, Canyon, Cisco) carbonates:
Traditional lithostratigraphic correlation



(adapted from Mazzullo, 1996)

Adjusted (biostrat-based) interpretation

- Backstepping /prograding diachronous limestone cycles (not a continuous, single limestone)
- Each cycle is capped by an exposure surface underlain by secondary porosity zone
- Opportunity for numerous, isolated stratigraphic traps; especially in downdip “stranded” units

STRAWN PETROLEUM SYSTEM

Reservoirs

Source

Traps

Seal

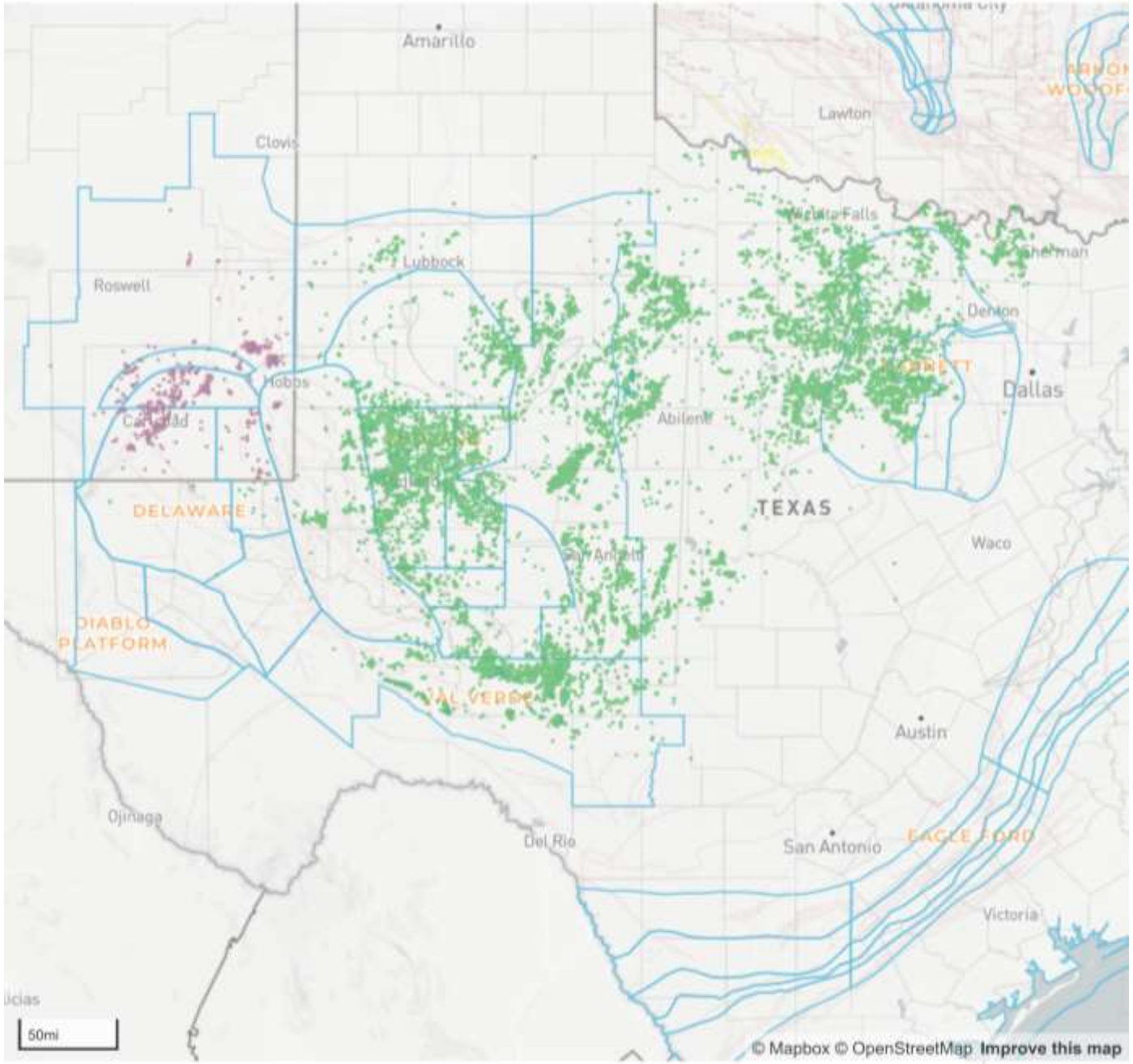
BEG Plays/Provinces: Strawn

Galloway et al., 1983, Atlas of Major Texas Oil Reservoirs

- Caddo reef (Bend Arch)
- Horseshoe Atoll
  - primarily Canyon-Cisco
- Ft. Chadbourne Fault (Eastern Shelf)
- Penn platform carbonate (CBP, Eastern Shelf)
  - includes Caddo, Odom, Goen, and Capps limestones
- Penn reef/bank (Eastern Shelf)
- Strawn sandstone (Eastern Shelf Bend Arch, FW Basin)

Dutton et al., 2004, Play Analysis and Digital Portfolio of Major Oil Reservoirs in the Permian Basin

- Northwest Shelf Strawn Patch Reef
- Penn Platform Carbonate
- Penn – L. Permian Horseshoe Atoll Carbonate
  - primarily Canyon-Cisco and L. Wolfcamp
- Penn – L. Permian Reef/Bank
- U. Penn – L. Permian Slope & Basinal Sandstone
- U. Penn Shelf Sandstone



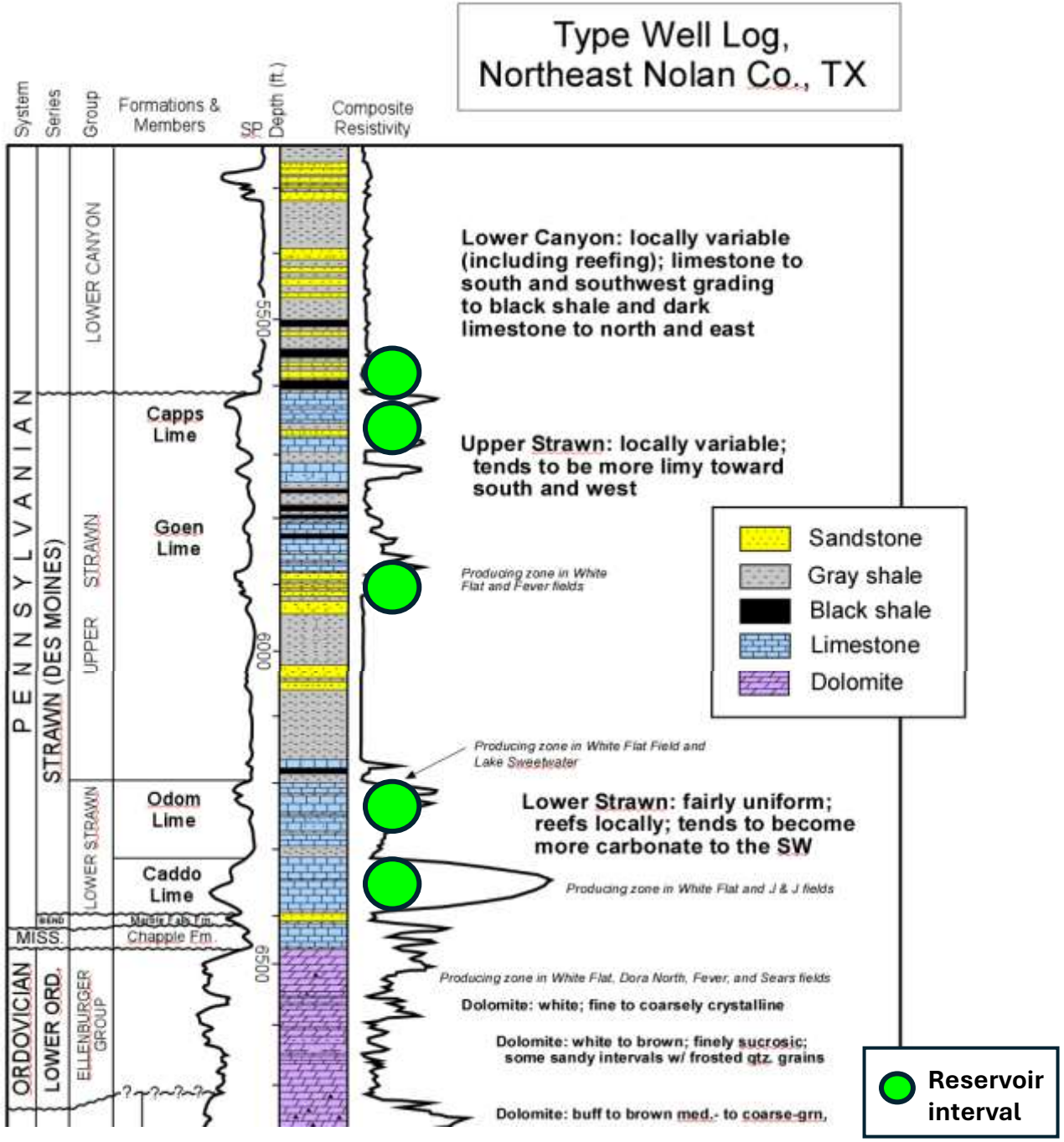
Strawn reservoirs (Enverus data base)

STRAWN STRAWN
SAND STRAWN
REEF STRAWN
UPPER STRAWN
LOWER STRAWN
LM. STRAWN TOP
ATOKA | STRAWN
STRAWN NORTH
STRAWN GAS
STRAWN DETRITAL
STRAWN - DISPOSAL
STRAWN CONGLOM.
CANYON | STRAWN
STRAWN SD. STRAWN
DETRITUS 2600
STRAWN SD
FUSSELMAN | STRAWN
CANYON,STRAWN
WOLFCAMP, STRAWN SS
STRAWN SD
STRAWN NORTH GAS
STRAWN 3, 700 STRAWN
3820 STRAWN 3100
ELLENBURGER,STRAWNA
TOKA,STRAWN STRAWN
3600
STRAWN 4600
GAS,STRAWN
PENN STRAWN
STRAWN 2400
CADDO,STRAWN STRAWN
SOUTH STRAWN,WOLFCAMP
STRAWN 3700 SAND

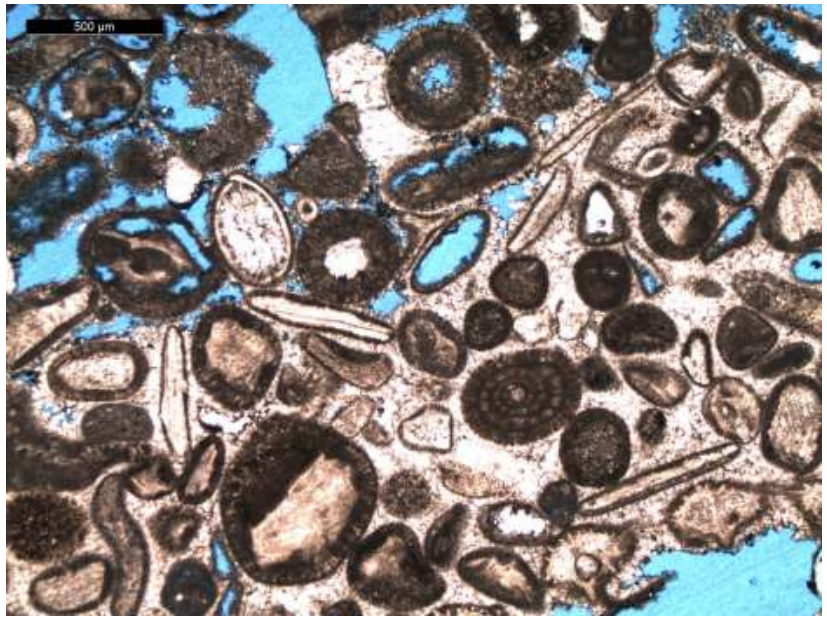
STRAWN-OIL
STRAWN EAST GAS
STRAWN 1700
STRAWN WEST
STRAWN 4200
THIRD STRAWN
STRAWN 5400
STRAWN 3200
STRAWN GRANNY SD.
CANYON,STRAWN
NORTH, STRAWN II
STRAWN 3300
STRAWN SOUTH GAS
STRAWN B
STRAWN WEST GAS
ELLEN,STRAWN
STRAWN SANDS
STRAWN A
STRAWN BASE OF
STRAWN 1900
STRAWN 3500
UPPER STRAWN
CANYON SAND,STRAWN
STRAWN C
ATOKA,MISS.,U. STRAWN
STRAWN LS
STRAWN C-1
STRAWN G
STRAWN 2500
STRAWN ZONE B
STRAWN MIDDLE
CANYON,ELLEN.,STRAWN
ATOKA | MISS | STRAWN UP.

STRAWN 9500
STRAWN 4300
ELLEN.,STRAWN TOP
STRAWN LIME
STRAWN 3900 SAND
STRAWN 4700
STRAWN 2100
STRAWN 1950
1200 STRAWN,
STRAWN 3680,
STRAWN 4970,
STRAWN 4575,
T/STRAWN

- Permian Basin, Eastern Shelf/Bend Arch, and Ft. Worth Basin
- Cyclic deposition (sandstones and carbonates)



J&J (Caddo Limestone) Field
Nolan County, TX

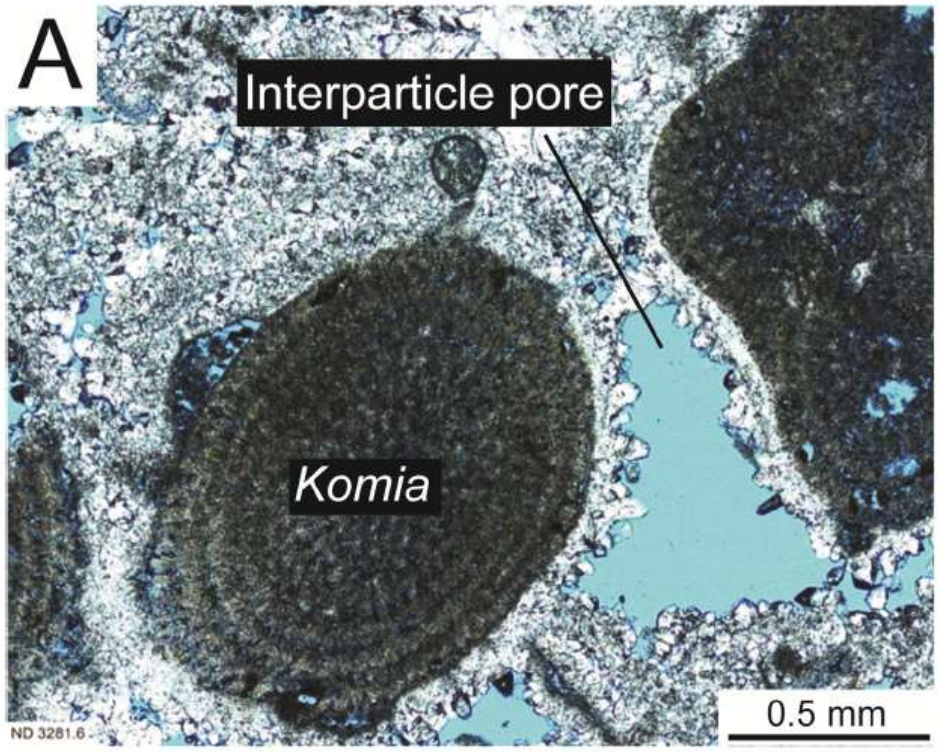


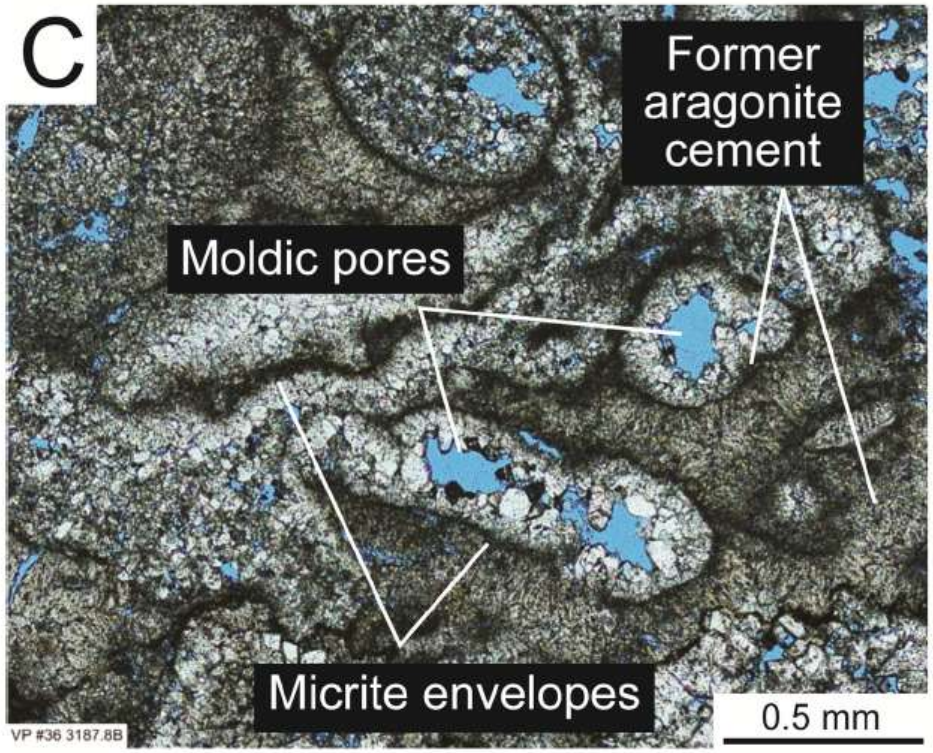
Highly porous skeletal-ooid grainstone

- *Intra- and interparticle primary & secondary porosity*
- *Dolomite porosity*

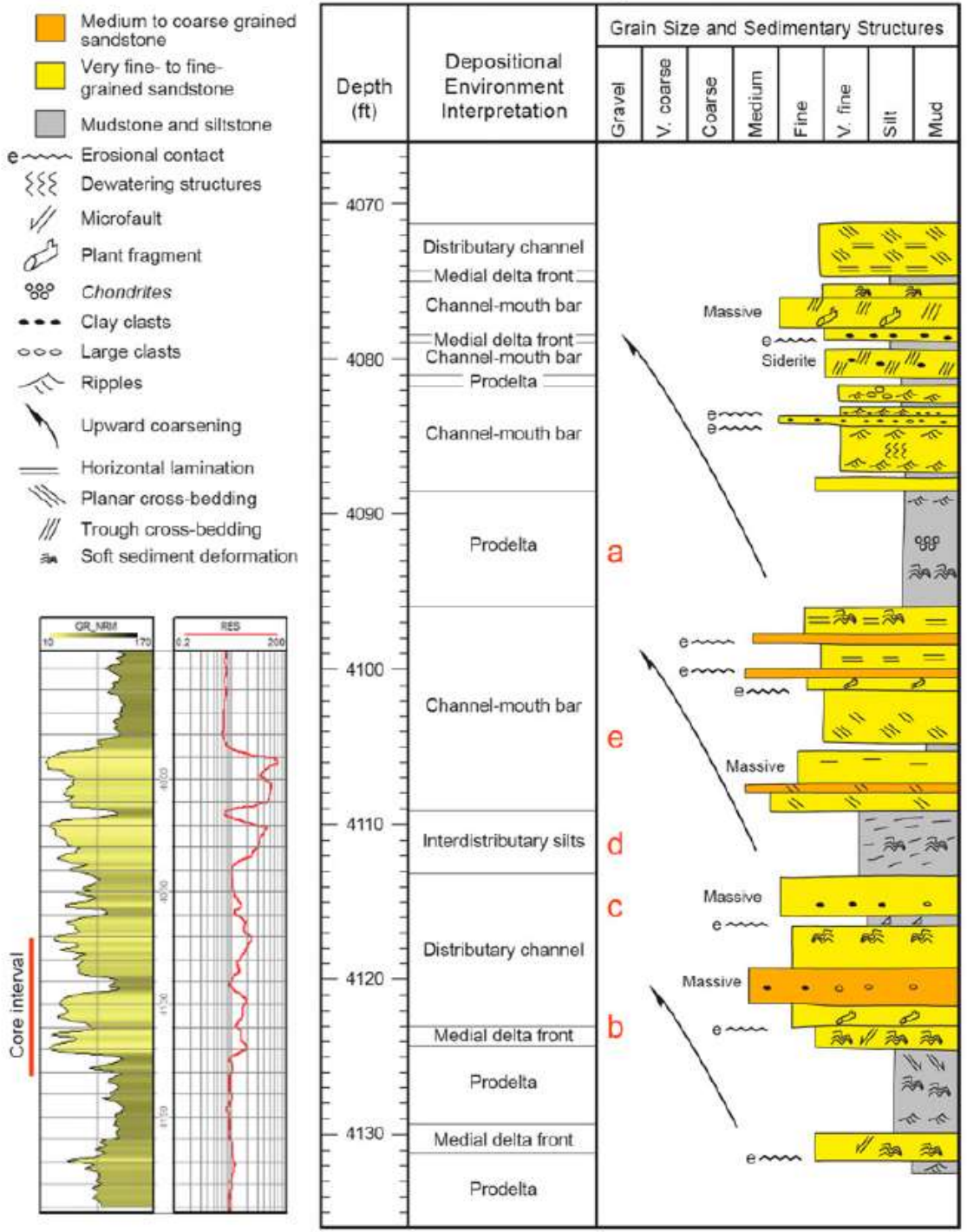
(Vazquez, 2023, UTD Perm. Basin Res. Lab)

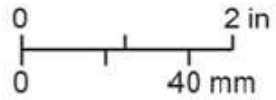
Dual pore system (macro- and microporosity) in Caddo buildups, Bend Arch





(Loucks and Fu, 2016)



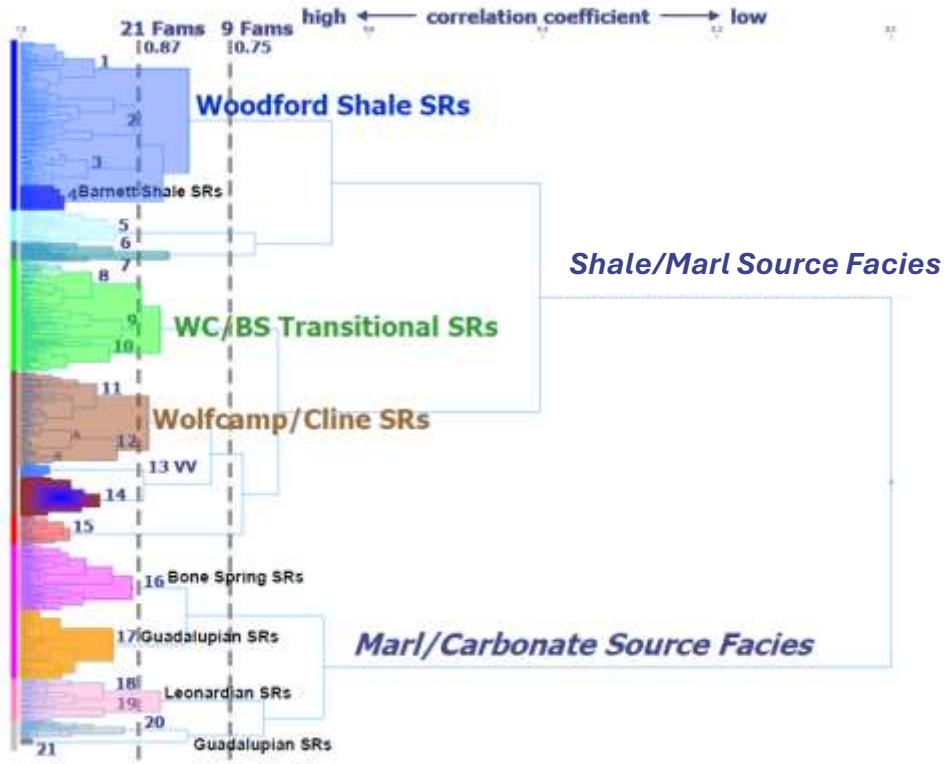


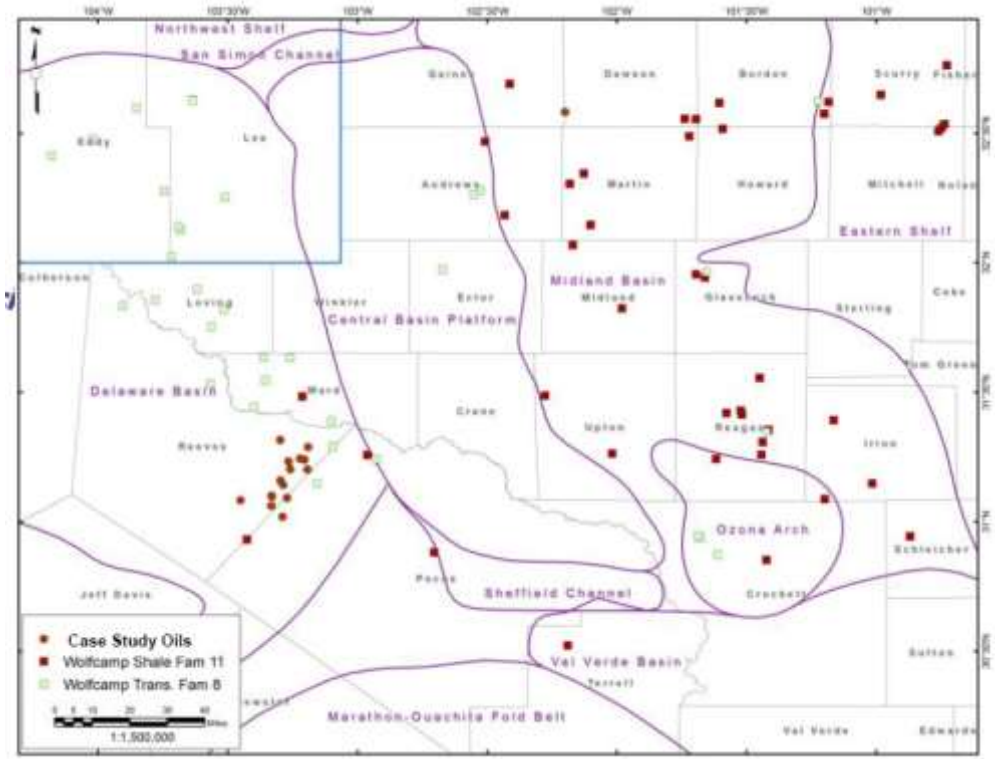
Lower Strawn fluvio-deltaic sandstones, Bend Arch – Ft. Worth Basin, Jack and Wise counties

Roberts et al., 2022, AAPG Bulletin)

Source Rocks for Strawn Reservoirs

- Likely migrated from several older and/or younger intervals (shale, shale/marl, & marl/carbonate facies)
  - Wolfcamp A - B
  - Woodford and/or Barnett
- Strawn-age portion of Wolfcamp D shales may be a significant source

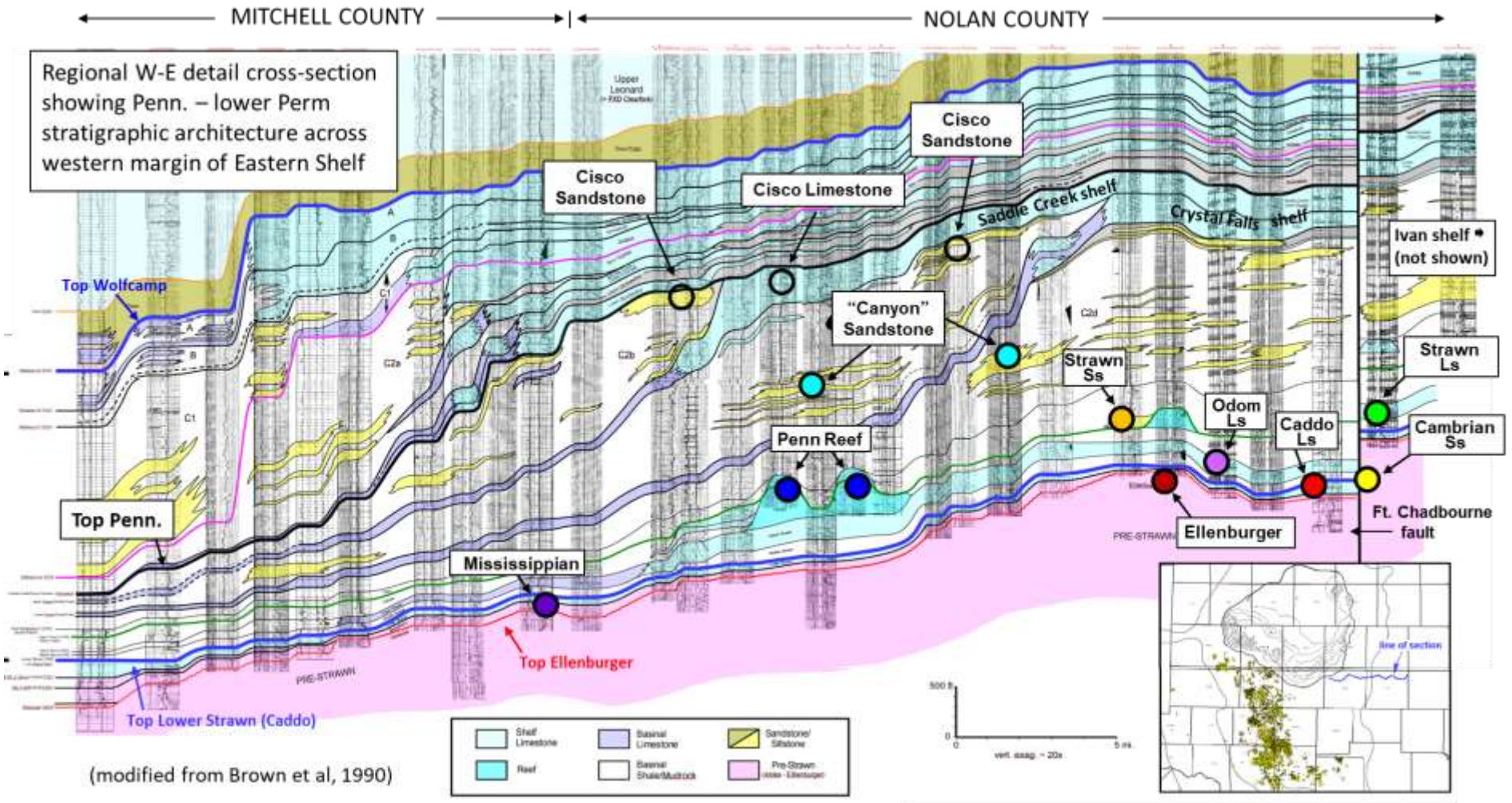




Perm. Basin oil families based on biomarkers and carbon isotopes

(Curtis and Zumberge, 2018, URTEC)

Strawn petroleum system: Traps and seals



Structural traps

- Fault traps
- Drape over Ellenburger. basement highs

Stratigraphic traps

- Channels
- Isolated bars
- Reefs and banks
- Diagenetic traps

Combination traps

- Some configuration of two or more above types

Strawn reservoirs are sealed by overlying shales of Wolfcamp D - Cisco Group

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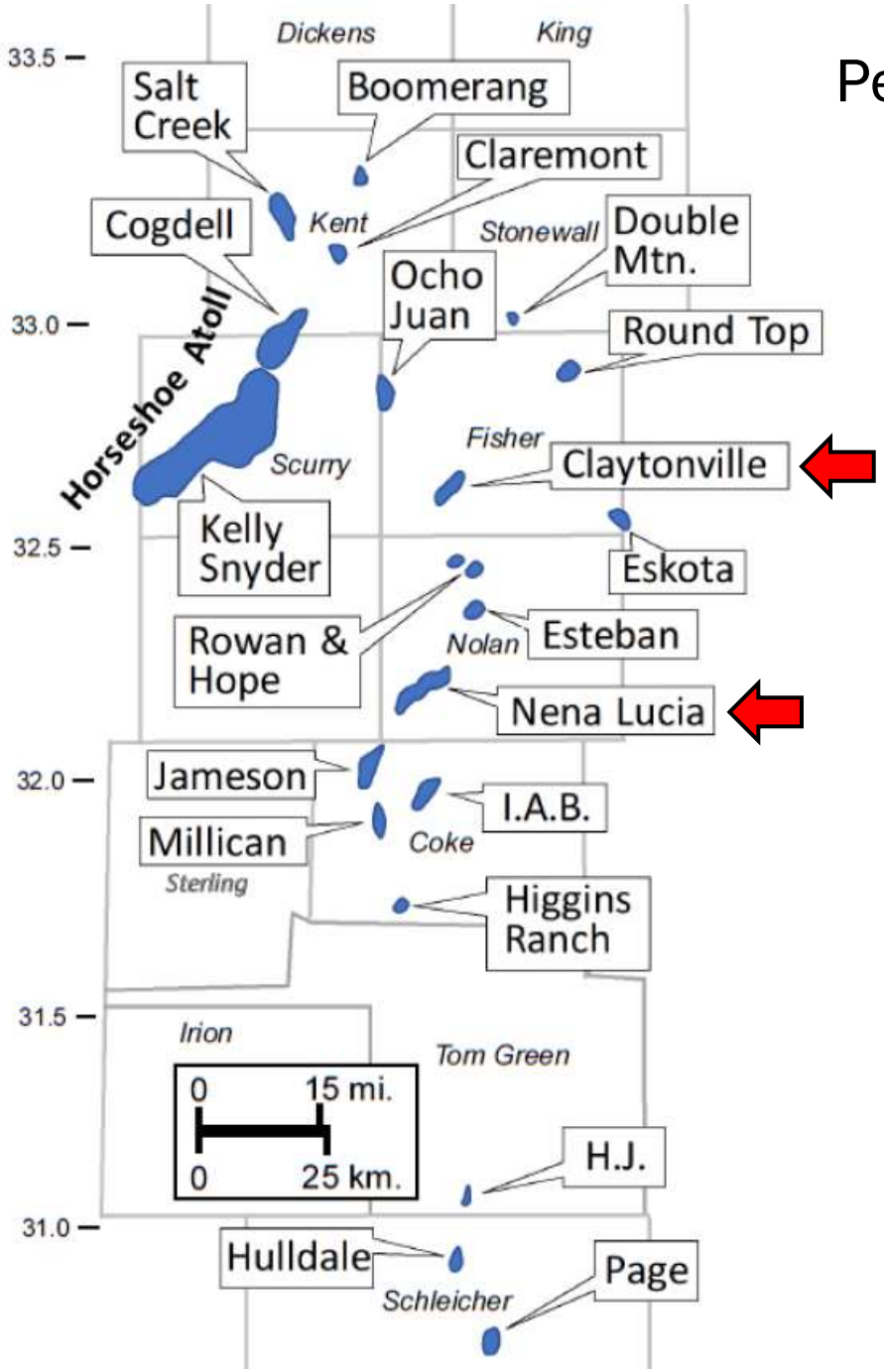
- Introduction
  - Carboniferous time scale
  - Penn. global themes and regional geologic setting
  - Penn. sea-level changes
  - Strawn paleogeography
- Strawn Group stratigraphy
  - N. Central Texas outcrops
  - Subsurface
  - Fusulinid biozones of the Permian Basin
- Strawn petroleum system
- **Strawn reefs of the Eastern Shelf**
- Summary and conclusions

Penn Reef Trend, Eastern Shelf (from Counselman, 1960)



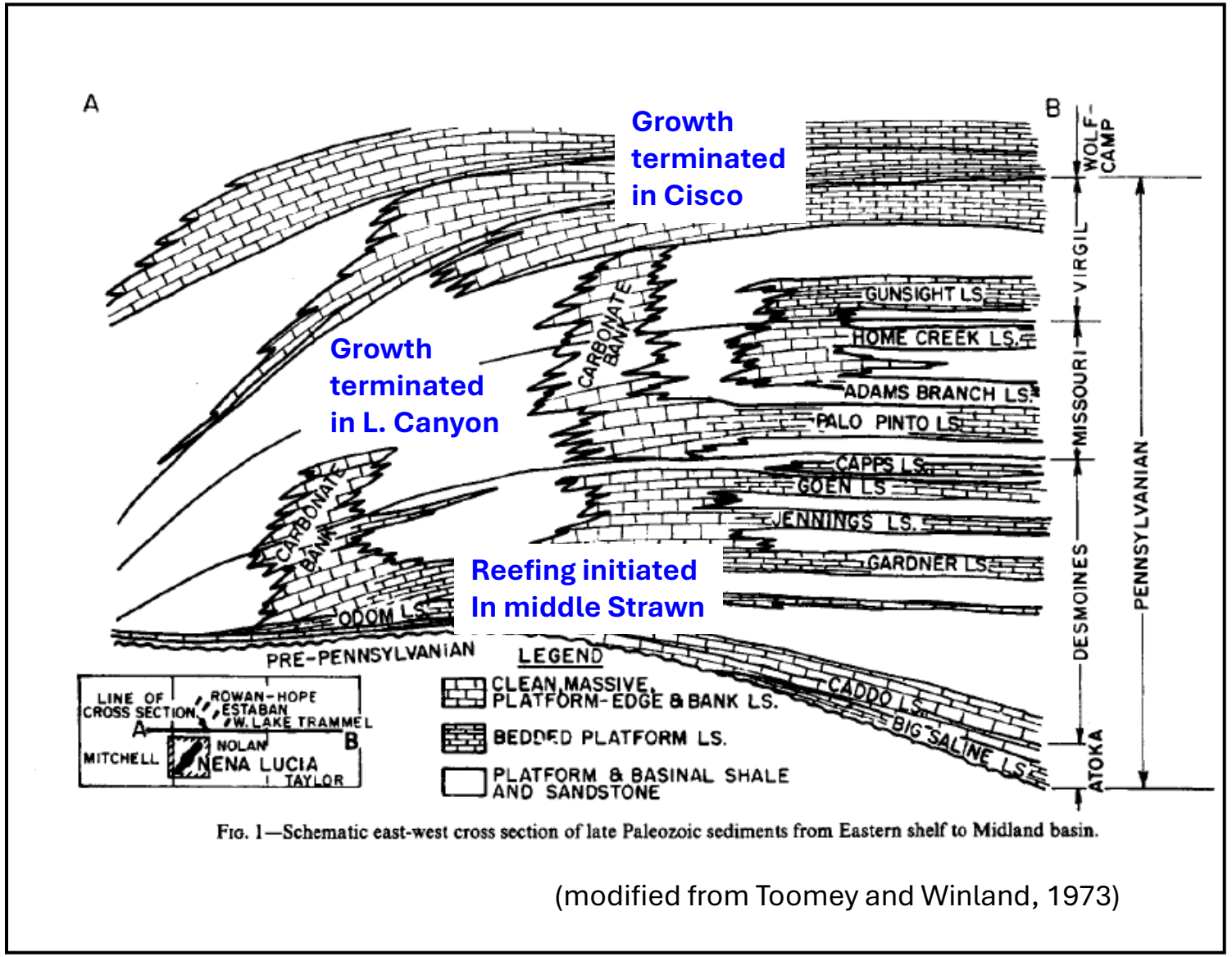
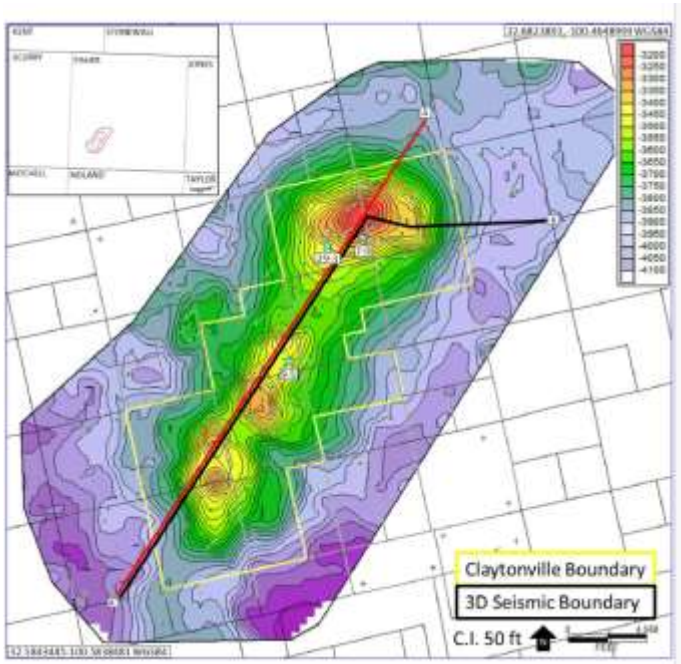
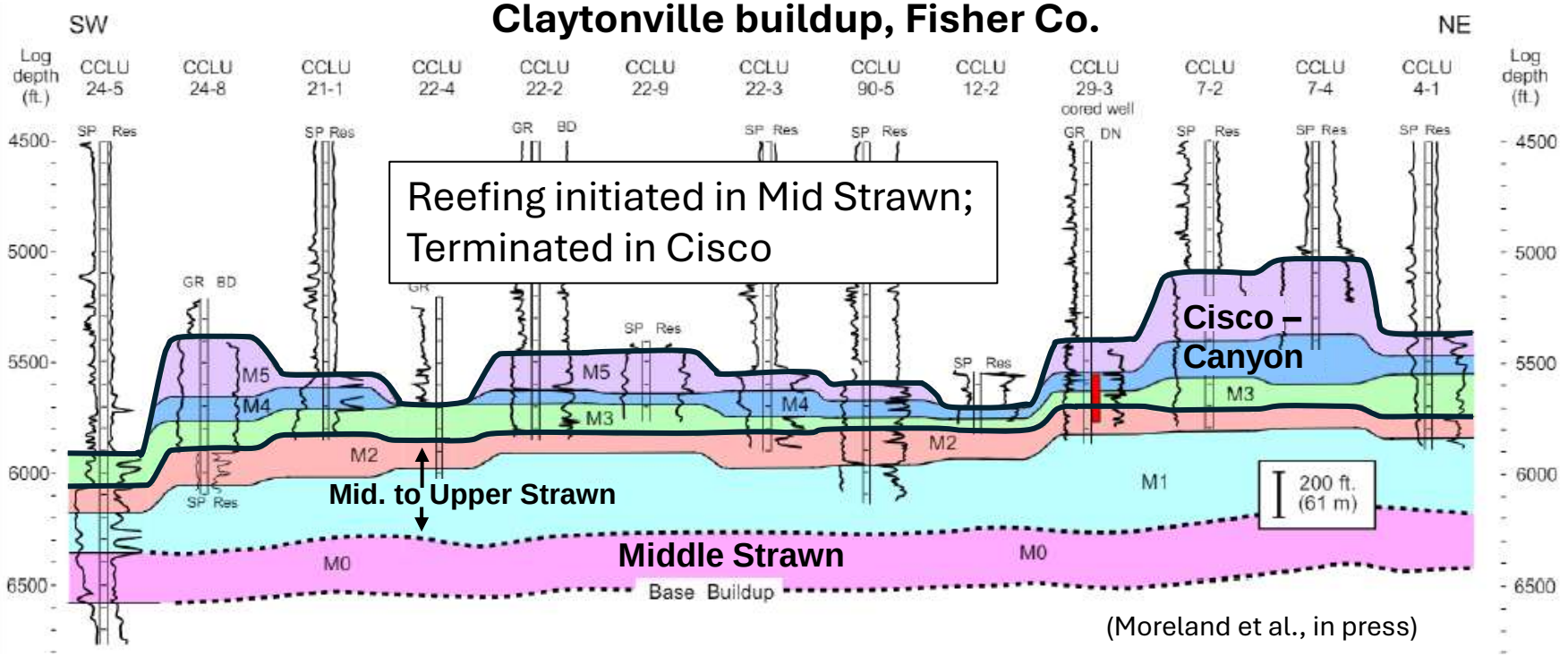


FIG. 1—Schematic east-west cross section of late Paleozoic sediments from Eastern shelf to Midland basin.

(modified from Toomey and Winland, 1973)



Claytonville buildup, Fisher Co.



(Moreland et al., in press)

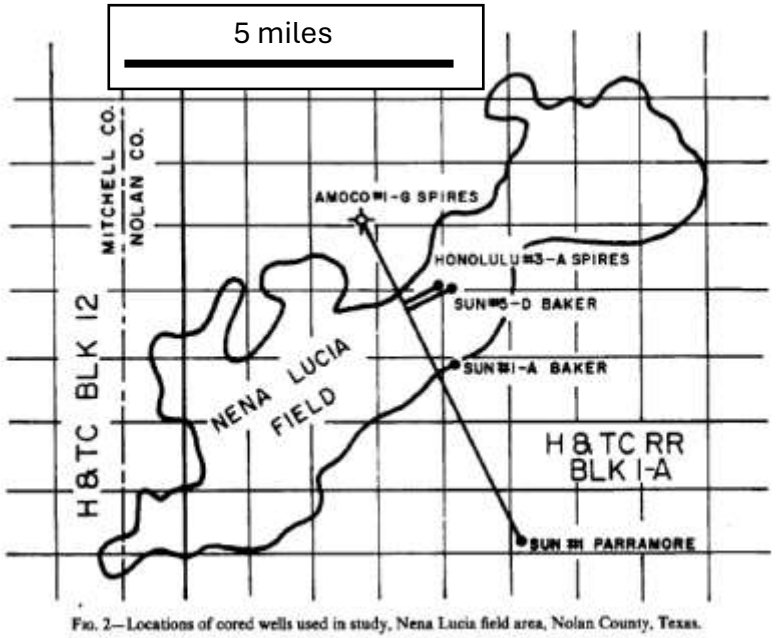
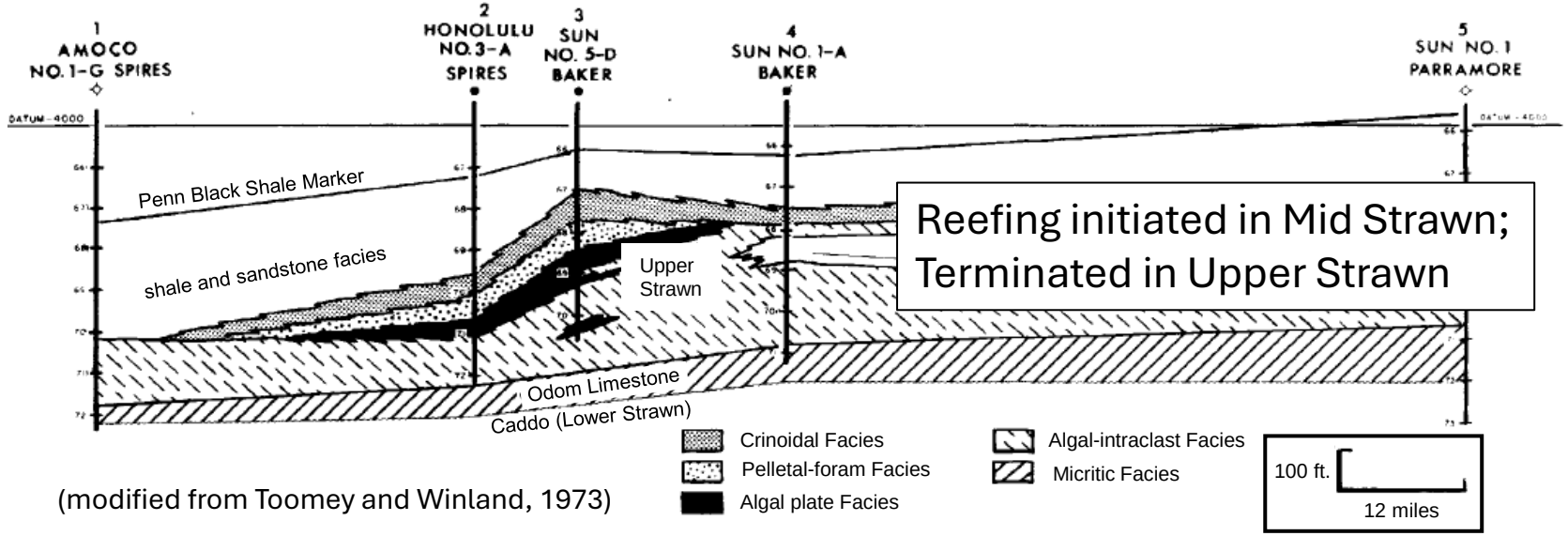
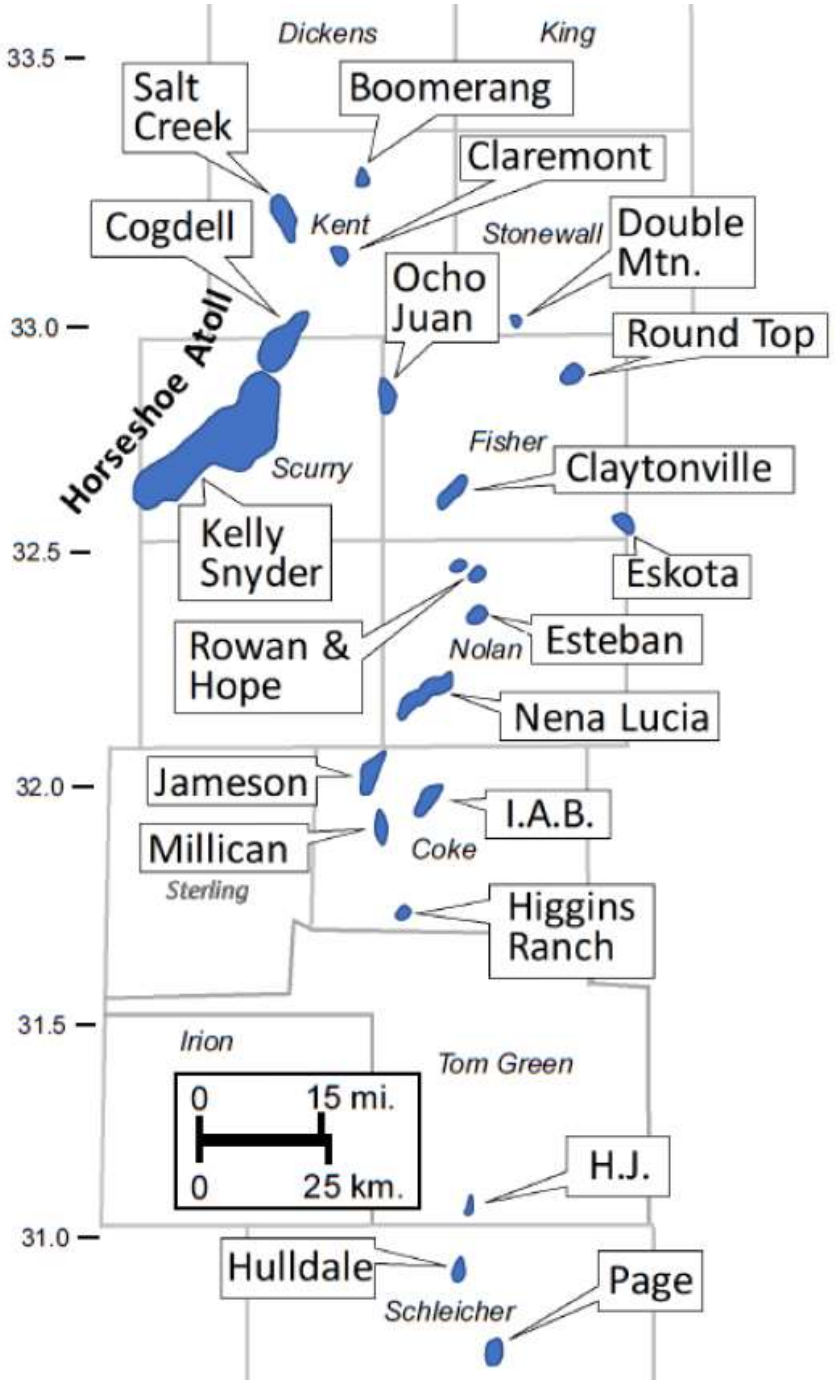


FIG. 2—Locations of cored wells used in study, Nena Lucia field area, Nolan County, Texas.

Nena Lucia buildup, Nolan Co.



(modified from Toomey and Winland, 1973)



Penn buildups of the Eastern Shelf

Vision quest (academic side)

- A more complete map of ***all*** Penn buildups
- Compilation of termination ages
- Investigation of termination cause(s)
- Literature review
- Additional core description

Vision quest (industry side)

- Apply biostrat-inspired correlation scheme (e.g., low-angle clinoforms) to identify position of lowstand units
- Deliberate search for strat traps (Ss / Ls)

Strawn Group of Texas: Summary and conclusions

- Strawn Group units are the product of the Pennsylvanian world:
  - Active tectonics during the assembly of Pangea (intersection of Ouachita-Marathon FTB and Ancestral Rockies)
  - Short-term glacioeustatic sea level changes (cyclothems) superimposed on long-term rise of Penn seaway
  - Predominance of marine invertebrates with aragonite / high magnesium calcite shells

- Strawn Group terminology differs for surface and subsurface units; fusulinid biostratigraphy helps constrain stratigraphic correlations (diachronous units)

- Strawn petroleum system is prolific and diverse
  - Multiple play types
  - Numerous sandstone and limestone reservoirs
  - Various source rocks likely, depending on sub-regon, including Wolfcamp A-B, lower Wolfcamp D (Strawn age); Woodford, and Barnett
  - Structural, stratigraphic, and combination traps, sealed by overlying lower Permian shales

- Call for data / collaborative projects on Penn buildups; deliberate search for remaining strat traps