

Recalibration of the Zarah Subgroup (upper Pennsylvanian, Missourian Stage) of Eastern Kansas and its Impact on Regional Stratigraphic Nomenclature

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2016, KU Geotech Meeting

Kansas Geological Survey
Open-File Report 2022-9

APAC Quarry, north of Louisburg, Kansas

 THE UNIVERSITY OF IOWA



Department of Earth &
Environmental Sciences

Outline

- 1) Paleogeography; Present Nomenclature; Previous Interpretation as of 1990 and the stratigraphic questions that arose with that research
- 2) New depositional interpretation and new unit identification
- 3) Implications of this research and recommendations for the future.

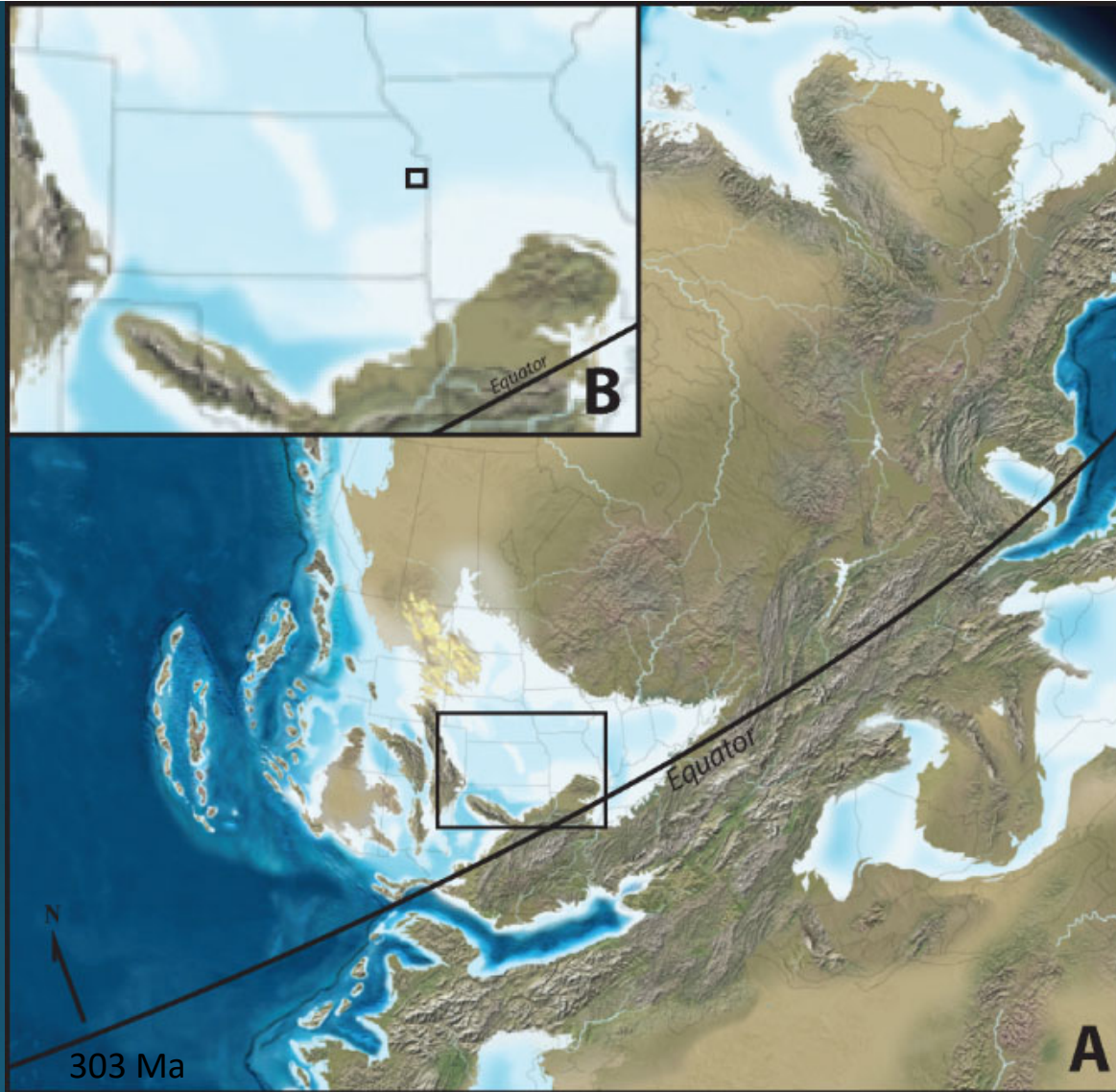
Tools utilized in the development of this model

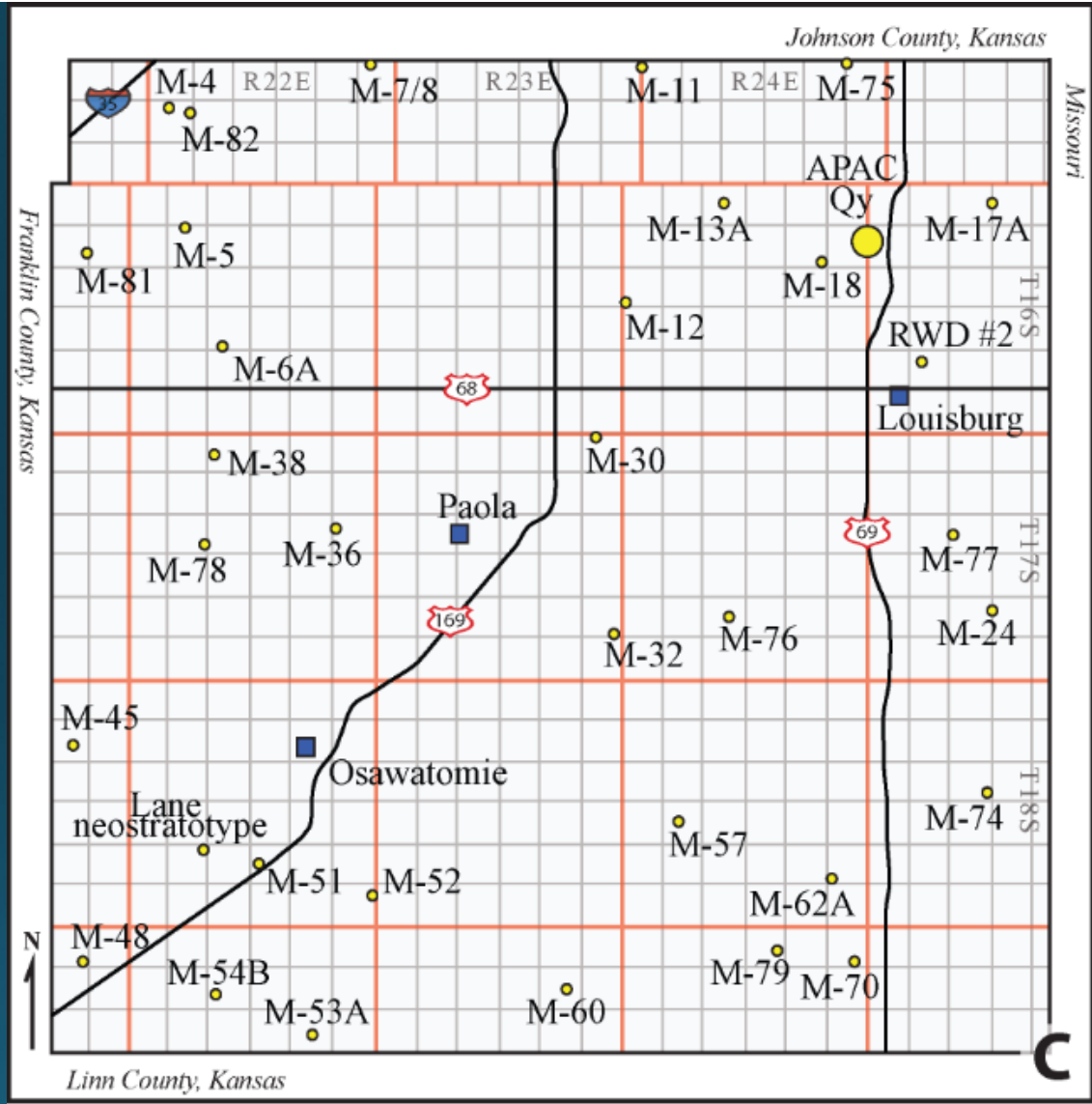


- cm-scale lithostratigraphic analyses of 33 drill core
- 57 samples for conodont biostratigraphy (> 14,000 Pa elements)
- 681 stable isotope ($\delta^{13}\text{C}_{\text{carb}}$) chemostratigraphy at 4-to-6-inch resolution
- geophysical (aeromagnetic and aerogravitational) maps
- 166 geophysical well-logs

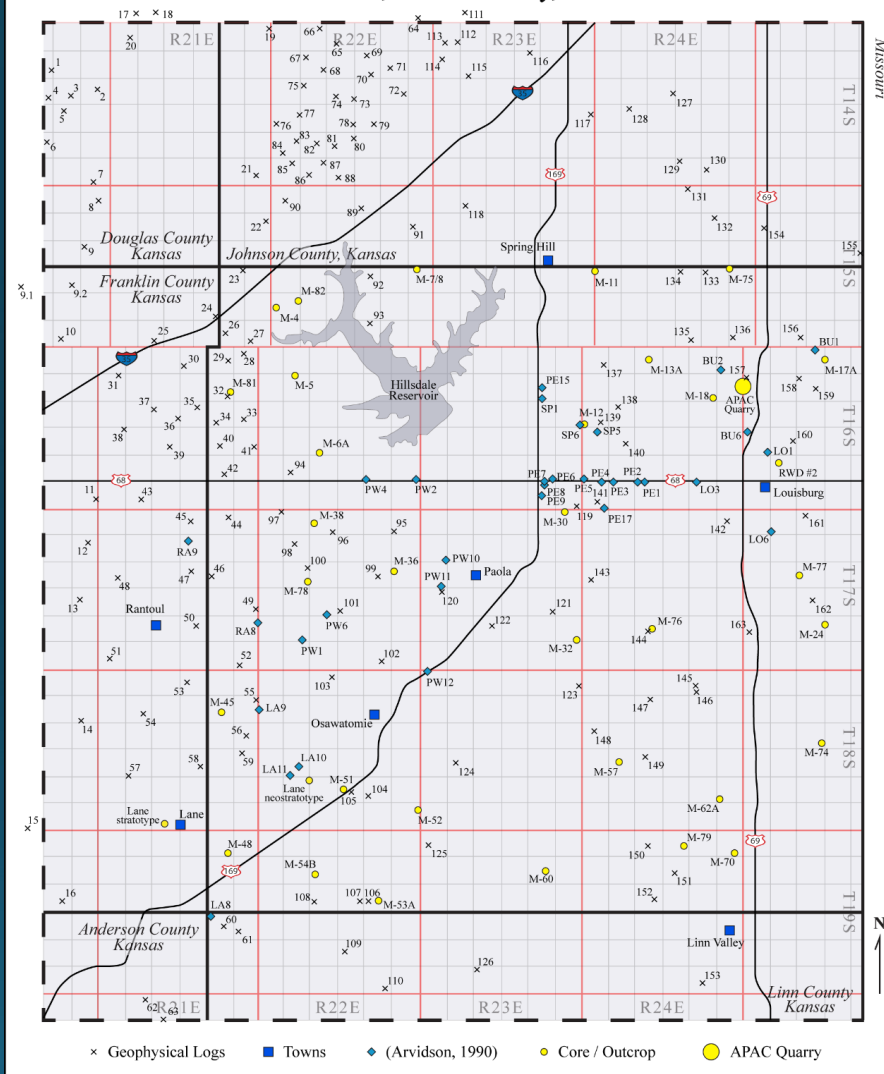
Conodont Elements

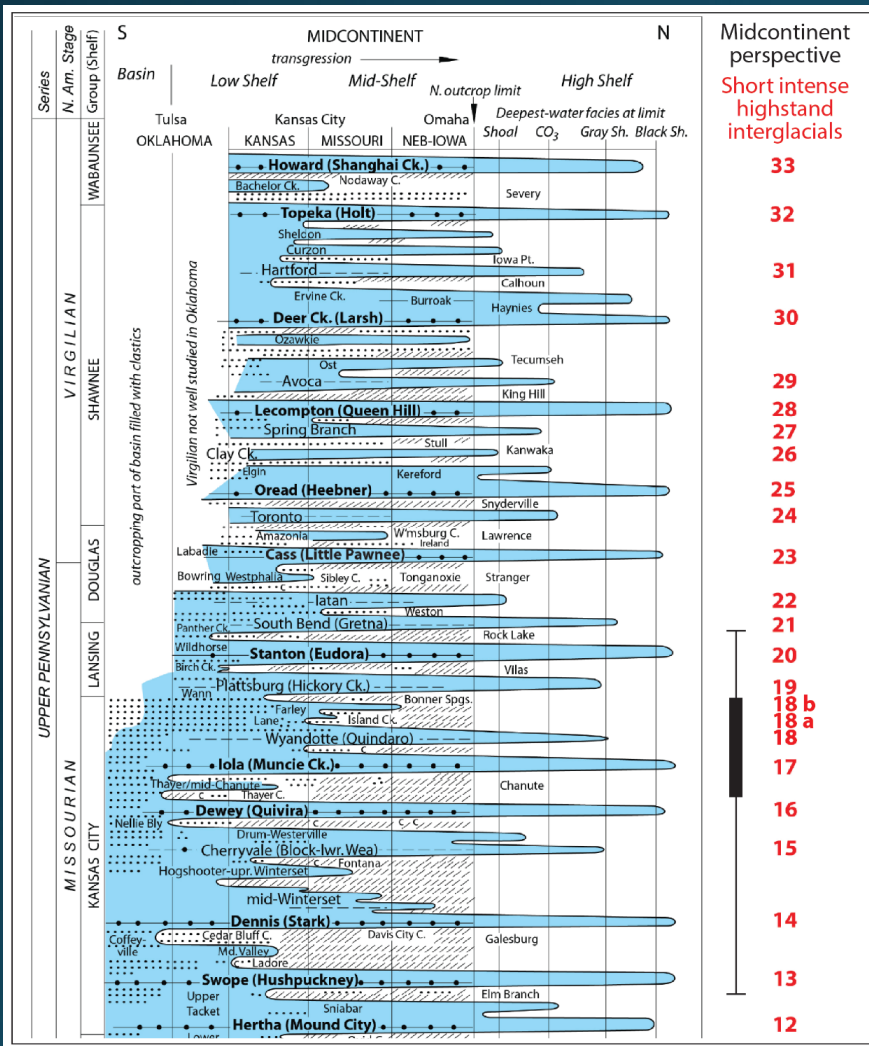






Data Localities, Miami County, NE Kansas

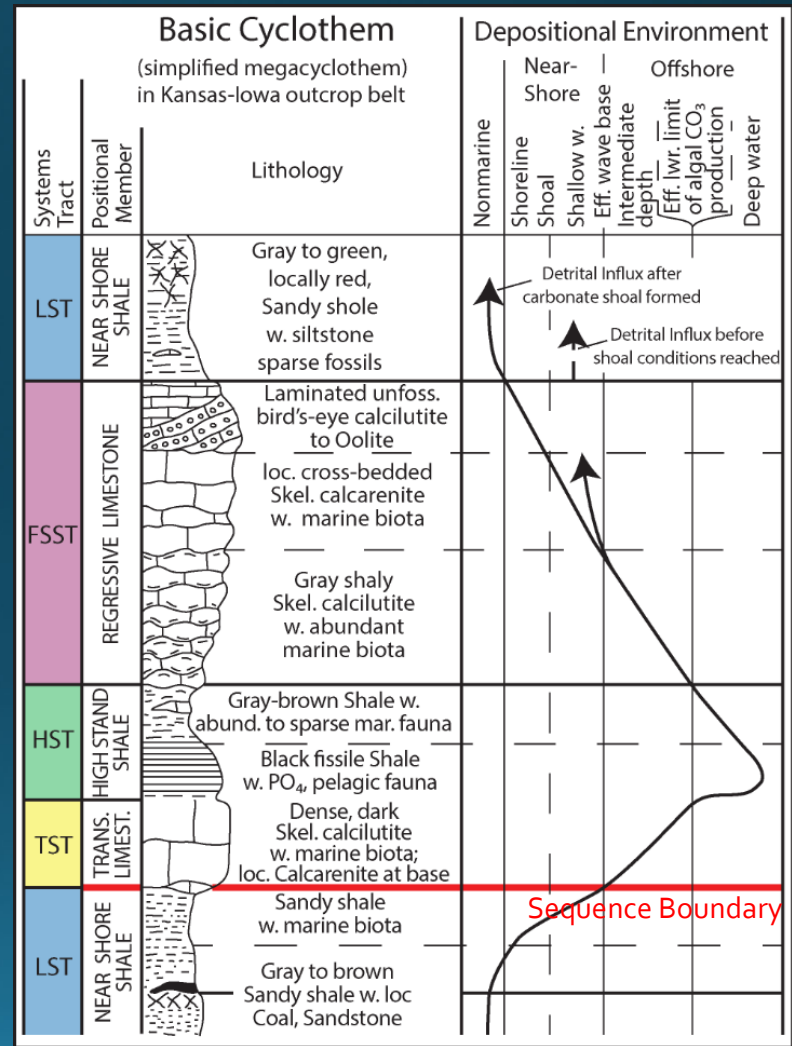




(modified from Heckel, 2013)

How were these strata deposited?

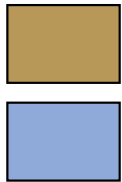
This cyclical pattern impacts nomenclature



(modified from Heckel, 2013)

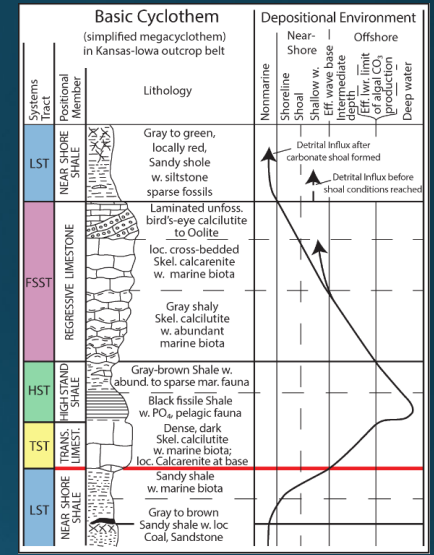
Nomenclature

Formations Studied



Limestone Dominated
Shale Dominated

		OLD CLASSIFICATION (Zeller, editor, 1968)	NEW CLASSIFICATION for KANSAS (Heckel and Watney, 2002)			
		south	north			
MISSOURIAN STAGE	LANSING GROUP	STANTON LS.	South Bend Ls. Mbr.	Little Kaw Ls. Mbr.	S. BEND LS.	
			Rock Lake Sh. Mbr.	ROCK LAKE SH.		
			Stoner Ls. Mbr.	3 beds Stoner Ls. Mbr.	STANTON LS.	
			Eudora Sh. Mbr.	Eudora Sh. Mbr.		
			Captain Creek Ls. Mbr.	2 beds Captain Creek Ls. Mbr.		
	VILAS SH.		VILAS SH.			
	PLATTSBURG LS.	Spring Hill Ls. Mbr.	Spring Hill Ls. Mbr.	PLATTSBURG LS.		
		Hickory Creek Sh. Mbr.	Hickory Creek Sh. Mbr.			
		Merriam Ls. Mbr.	Merriam Ls. Mbr.			
	KANSAS CITY GROUP	ZARAH SUBGROUP	BONNER SPRINGS SH.		Bonner Springs Sh. Mbr.	LANE SH.
Farley Ls. Mbr.			Farley Ls. Mbr.			
Island Creek Sh. Mbr.			Island Creek Sh. Mbr.			
Argentine Ls. Mbr.			Argentine Limestone Mbr.			
Quindaro Sh. Mbr.			Quindaro Shale Mbr.			
WYANDOTTE LS.		Frisbie Ls. Mbr.		Frisbie Limestone Mbr.	WYANDOTTE LS.	
		LANE SH.		LIBERTY MEMORIAL SH.		
		IOLA LS.	Raytown Ls. Mbr.	Raytown Limestone Mbr.		IOLA LS.
			Muncie Creek Sh. Mbr.	Muncie Creek Shale Mbr.		
			Paola Ls. Mbr.	Paola Limestone Mbr.		
CHANUTE SH.	Cottage Grove Ss. Mbr.	Cottage Grove Ss. bed Thayer coal bed	CHANUTE SH.			
	Noxie Ss. Mbr.	Noxie Ss. bed				
DRUM LS.	Corbin City Ls. Mbr.	Cement City Ls. Mbr.	DEWEY LS.			
	Dewey Ls. Mbr.	Quivira Sh. Mbr.				
CHERRYVALE SH.	NELLIE BLY FORMATION		CHERRYVALE FORMATION			
	Quivira Sh. Mbr.	Drum Ls. Mbr.		Westerville Ls. Mbr.		
	Westerville Ls. Mbr.	Drum Ls. Mbr.		Westerville Ls. Mbr.		
	Wea Sh. Mbr.	Middle Flaggy Ls. Mbr.		Wea Sh. Mbr.		
	Block Ls. Mbr.	Block Ls. Mbr.		Block Ls. Mbr.		
DENNIS LS.	Fontana Sh. Mbr.	Fontana Sh. Mbr.	DENNIS LS.			
	Winterset Ls. Mbr.	Winterset Ls. Mbr.				
	Stark Sh. Mbr.	Stark Sh. Mbr.				
BRONSON SUBGROUP	GALESBURG SH.		Cedar Bluff coal bed	GALESBURG SH.		
	SWOPE LS.	Bethany Falls Ls. Mbr.	MOUND VALLEY LS.			
		Hushpuckney Sh. Mbr.	LADORE SH.			
		Middle Creek Ls. Mbr.	Bethany Falls Ls. Mbr.			
	LADORE SH.		Hushpuckney Sh. Mbr.		SWOPE LS.	
	ELM BRANCH SH.		Middle Creek Ls. Mbr.			
	HERTHA LS.	Sniabar Ls. Mbr.	Mid. Ls. Mbr.		Sniabar Ls. Mbr.	HERTHA LS.
		Mound City Sh. Mbr.	Mound City Sh. Mbr.			
		Critzer Ls. Mbr.	Guthrie Mountain Sh. Mbr.			
	PLEASANTON GROUP	TACKET FORMATION			Critzer Ls. Mbr.	SHALE HILL FORMATION
CHECKERBOARD LIMESTONE		Mantey Sh. Mbr.				
SEMINOLE FORMATION		South Mound Sh. Mbr.	Exline Ls. Mbr.			
		Helper Ss. Mbr.	Helper Ss. Mbr.			

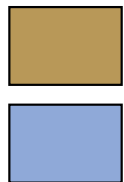


(modified from Heckel, 2013)

(after Heckel & Watney, 2002)

Nomenclature

Formations Studied



Limestone Dominated
Shale Dominated

- using Heckel & Watney (2002)
- Farley Limestone Mbr. is divided into Lower, Middle, and Upper units
- Farley subdivision represents two minor cycles

MISSOURIAN STAGE	LANSIN	VILAS SH.		VILAS SH.		LANSIN
		PLATTSBURG LS.	Spring Hill Ls. Mbr.	Spring Hill Ls. Mbr.	PLATTSBURG LS.	
			Hickory Creek Sh. Mbr.	Hickory Creek Sh. Mbr.		
	Merriam Ls. Mbr.		Merriam Ls. Mbr.			
	ZARAH SUBGROUP	BONNER SPRINGS SH.		BONNER SPRINGS SH. Mbr.		LANE SH.
		WYANDOTTE LS.	Farley Ls. Mbr.	Farley Ls. Mbr.	WYANDOTTE LS.	
			Island Creek Sh. Mbr.	Island Creek Sh. Mbr.		
			Argentine Ls. Mbr.	Argentine Limestone Mbr.		
		Quindaro Sh. Mbr.	Quindaro Shale Mbr.	WYANDOTTE LS.		
		Frisbie Ls. Mbr.	Frisbie Limestone Mbr.			
		LANE SH.		LIBERTY MEMORIAL SH.		IOLA LS.
		IOLA LS.	Raytown Ls. Mbr.	Raytown Limestone Mbr.		
			Muncie Creek Sh. Mbr.	Muncie Creek Shale Mbr.		
			Paola Ls. Mbr.	Paola Limestone Mbr.		
	CHANUTE SH.	Cottage Grove Ss. Mbr.	Cottage Grove Ss. bed	CHANUTE SH.		
Noxie Ss. Mbr.		Thayer coal bed				
		Noxie Ss. bed				
DRUM LS.	Corbin City Ls. Mbr.	Cement City Ls. Mbr.	DEWEY LS.			
	Dewey Ls. Mbr.					
	Quivira Sh. Mbr.	Quivira Sh. Mbr.	NELLIE BLY FORMATION			

MISSOURIAN STAGE

PENNSYLVANIAN SERIES

Nomenclature

Formations Studied



Limestone Dominated



Shale Dominated

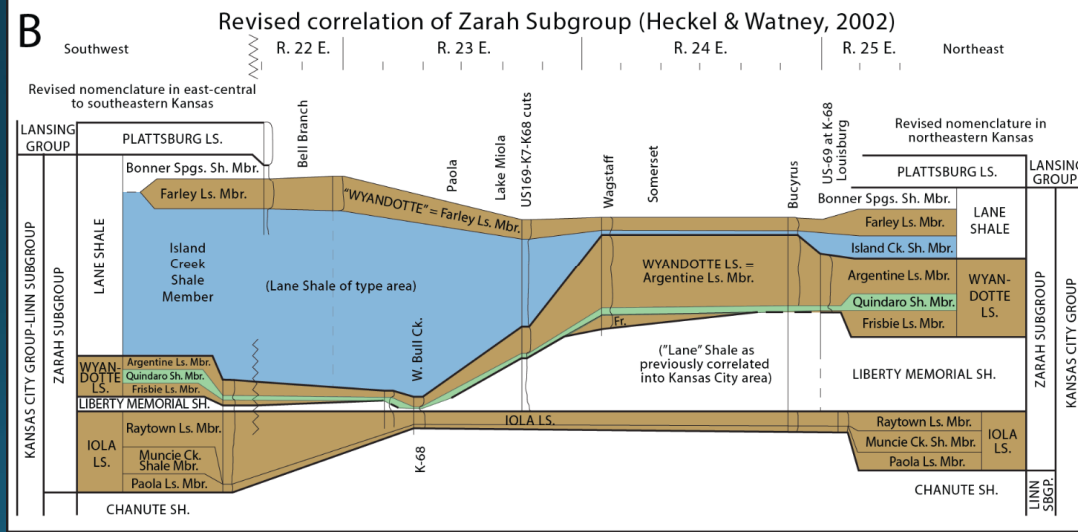
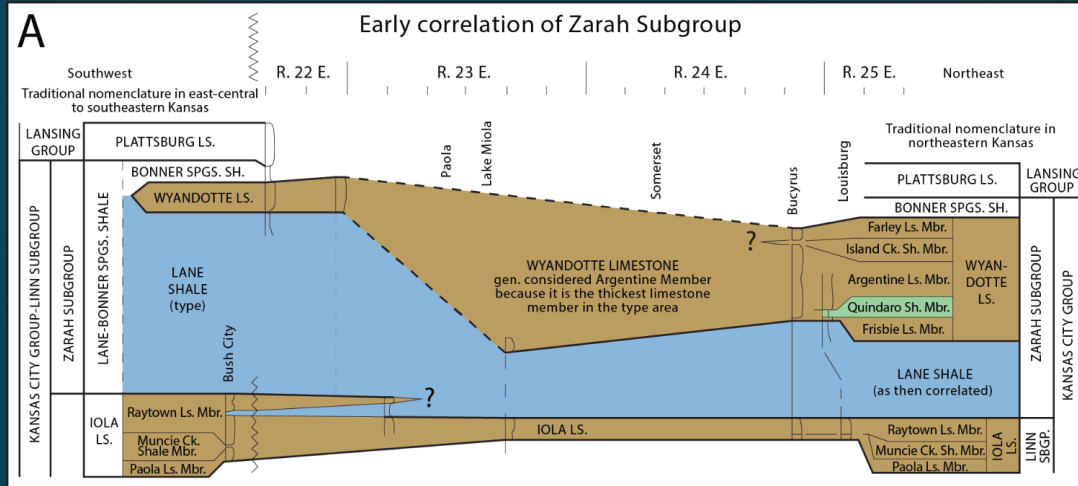
Why was there such significant revision to the Zarah Subgroup?

MISSOURIAN STAGE	LANSIN	VILAS SH.		VILAS SH.		LANSIN
		PLATTSBURG LS.	Spring Hill Ls. Mbr.	Spring Hill Ls. Mbr.	PLATTSBURG LS.	
			Hickory Creek Sh. Mbr.	Hickory Creek Sh. Mbr.		
	Merriam Ls. Mbr.		Merriam Ls. Mbr.			
	ZARAH SUBGROUP	BONNER SPRINGS SH.		BONNER SPRINGS SH. Mbr.		LANE SH.
		WYANDOTTE LS.	Farley Ls. Mbr.	Farley Ls. Mbr.	WYANDOTTE LS.	
			Island Creek Sh. Mbr.	Island Creek Sh. Mbr.		
			Argentine Ls. Mbr.	Argentine Limestone Mbr.		
		Quindaro Sh. Mbr.	Quindaro Shale Mbr.	WYANDOTTE LS.		
		Frisbie Ls. Mbr.	Frisbie Limestone Mbr.			
		LANE SH.		LIBERTY MEMORIAL SH.		IOLA LS.
		IOLA LS.	Raytown Ls. Mbr.	Raytown Limestone Mbr.	IOLA LS.	
			Muncie Creek Sh. Mbr.	Muncie Creek Shale Mbr.		
			Paola Ls. Mbr.	Paola Limestone Mbr.		
CHANUTE SH.	Cottage Grove Ss. Mbr.	Cottage Grove Ss. bed	CHANUTE SH.			
	Noxie Ss. Mbr.	Thayer coal bed				
		Noxie Ss. bed				
DRUM LS.	Corbin City Ls. Mbr.	Cement City Ls. Mbr.	DEWEY LS.			
	Dewey Ls. Mbr.					
	Quivira Sh. Mbr.	Quivira Sh. Mbr.	NELLIE BLY FORMATION			

MISSOURIAN STAGE

PENNSYLVANIAN SERIES

MISSOURIAN STAGE		OLD CLASSIFICATION (Zeller, editor, 1968)	
		KANSAS CITY GROUP	LANSING GROUP
KANSAS CITY GROUP	ZARAH SUBGROUP	WYANDOTTE LS.	South Bend Ls. Mbr.
			Rock Lake Sh. Mbr.
			Stoner Ls. Mbr.
			Eudora Sh. Mbr.
			Captain Creek Ls. Mbr.
	LINN SUBGROUP	CHANUTE SH.	Spring Hill Ls. Mbr.
			Hickory Creek Sh. Mbr.
			Merriam Ls. Mbr.
			Farley Ls. Mbr.
			Island Creek Sh. Mbr.
KANSAS CITY GROUP	ZARAH SUBGROUP	IOLA LS.	Argentine Ls. Mbr.
			Quindaro Sh. Mbr.
			Frisbie Ls. Mbr.
			Raytown Ls. Mbr.
			Muncie Ck. Shale Mbr.
KANSAS CITY GROUP	ZARAH SUBGROUP	LANE SH.	Paola Ls. Mbr.
			Cottage Grove Ss. Mbr.
			Noxie Ss. Mbr.
			Raytown Ls. Mbr.
			Muncie Creek Sh. Mbr.
KANSAS CITY GROUP	ZARAH SUBGROUP	BONNER SPRINGS SH.	Paola Ls. Mbr.
			Farley Ls. Mbr.
			Island Creek Sh. Mbr.
			Argentine Ls. Mbr.
			Quindaro Sh. Mbr.
KANSAS CITY GROUP	ZARAH SUBGROUP	PLATTSBURG LS.	Frisbie Ls. Mbr.
			Merriam Ls. Mbr.
			Hickory Creek Sh. Mbr.
			Spring Hill Ls. Mbr.
			WYANDOTTE LS.
KANSAS CITY GROUP	ZARAH SUBGROUP	LANE-BONNER SPGS. SHALE	WYANDOTTE LS.
			BONNER SPGS. SH.
			PLATTSBURG LS.
			LANE SH.
			LANE SH.
KANSAS CITY GROUP	ZARAH SUBGROUP	LANE SH.	LANE SH.
			LANE SH.
			LANE SH.
			LANE SH.
			LANE SH.
KANSAS CITY GROUP	ZARAH SUBGROUP	LANE SH.	LANE SH.
			LANE SH.
			LANE SH.
			LANE SH.
			LANE SH.



MISSOURIAN STAGE		NEW CLASSIFICATION for KANSAS (Heckel and Watney, 2002)	
		KANSAS CITY GROUP	LANSING GROUP
KANSAS CITY GROUP	ZARAH SUBGROUP	WYANDOTTE LS.	South Bend Ls.
			Rock Lake Shale
			Stoner Ls. Mbr.
			Eudora Sh. Mbr.
			Captain Creek Ls. Mbr.
	LINN SUBGROUP	CHANUTE SH.	Spring Hill Ls. Mbr.
			Hickory Creek Sh. Mbr.
			Merriam Ls. Mbr.
			Farley Ls. Mbr.
			Island Creek Sh. Mbr.
KANSAS CITY GROUP	ZARAH SUBGROUP	IOLA LS.	Argentine Ls. Mbr.
			Quindaro Sh. Mbr.
			Frisbie Ls. Mbr.
			Raytown Ls. Mbr.
			Muncie Creek Sh. Mbr.
KANSAS CITY GROUP	ZARAH SUBGROUP	LANE SH.	Paola Ls. Mbr.
			Cottage Grove Ss. Mbr.
			Noxie Ss. Mbr.
			Raytown Ls. Mbr.
			Muncie Creek Sh. Mbr.
KANSAS CITY GROUP	ZARAH SUBGROUP	BONNER SPRINGS SH.	Paola Ls. Mbr.
			Farley Ls. Mbr.
			Island Creek Sh. Mbr.
			Argentine Ls. Mbr.
			Quindaro Sh. Mbr.
KANSAS CITY GROUP	ZARAH SUBGROUP	PLATTSBURG LS.	Frisbie Ls. Mbr.
			Merriam Ls. Mbr.
			Hickory Creek Sh. Mbr.
			Spring Hill Ls. Mbr.
			WYANDOTTE LS.
KANSAS CITY GROUP	ZARAH SUBGROUP	LANE SH.	LANE SH.
			LANE SH.
			LANE SH.
			LANE SH.
			LANE SH.
KANSAS CITY GROUP	ZARAH SUBGROUP	LANE SH.	LANE SH.
			LANE SH.
			LANE SH.
			LANE SH.
			LANE SH.

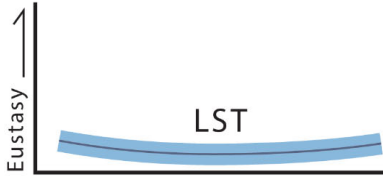
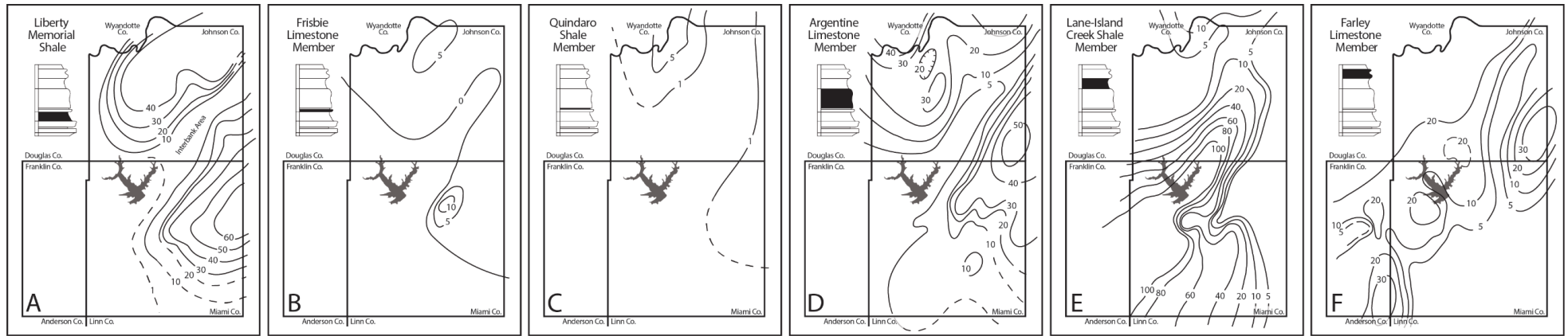
Previous Interpretation

Most recent study
of the Zarah
interval comes
from Arvidson
(1990)

NEW CLASSIFICATION for KANSAS
(Heckel and Watney, 2002)

MISSOURIAN STAGE	LANSING GROUP	SOUTH BEND LS.	Little Kaw Ls. Mbr.	
		ROCK LAKE SHALE		
		STANTON LS.	Stoner Ls. Mbr.	
			Eudora Sh. Mbr.	
			Captain Creek Ls. Mbr.	
		VILAS SH.		
		PLATTSBURG LS.	Spring Hill Ls. Mbr.	
			Hickory Creek Sh. Mbr.	
			Merriam Ls. Mbr.	
		KANSAS CITY GROUP	ZARAH SUBGROUP	
	LANE SH.			Farley Ls. Mbr.
				Island Creek Sh. Mbr.
	WYANDOTTE LS.			Argentine Ls. Mbr.
				Quindaro Sh. Mbr.
			Frisbie Ls. Mbr.	
LIBERTY MEMORIAL SHALE				
IOLA LS.	Raytown Ls. Mbr.			
	Muncie Creek Sh. Mbr.			
	Paola Ls. Mbr.			
LINN	CHANUTE SH.	Cottage Grove Ss. Mbr.		
		Noxie Ss. Mbr.		

Previous Interpretation

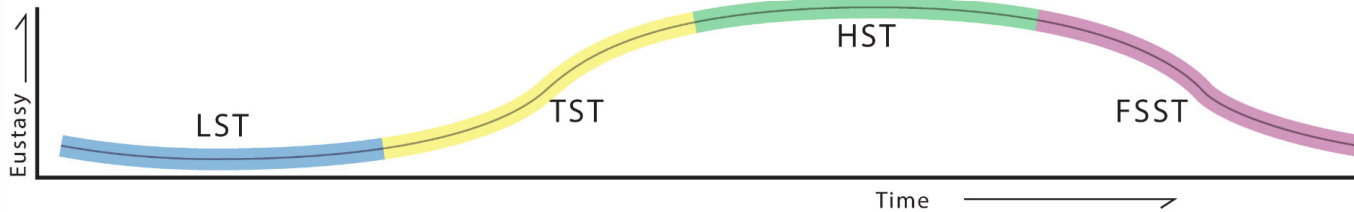
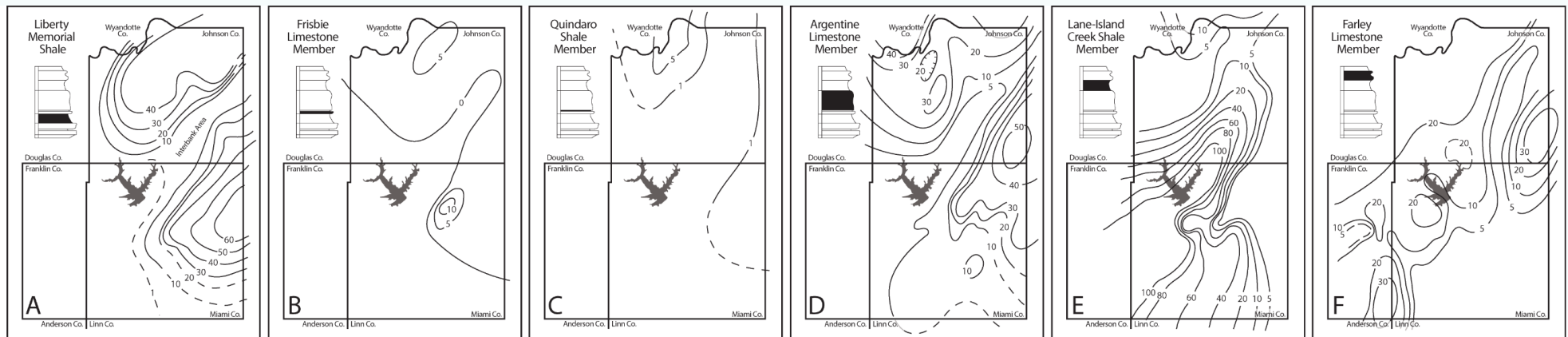


Time →

Note: build-and-fill

(after Arvidson, 1990)

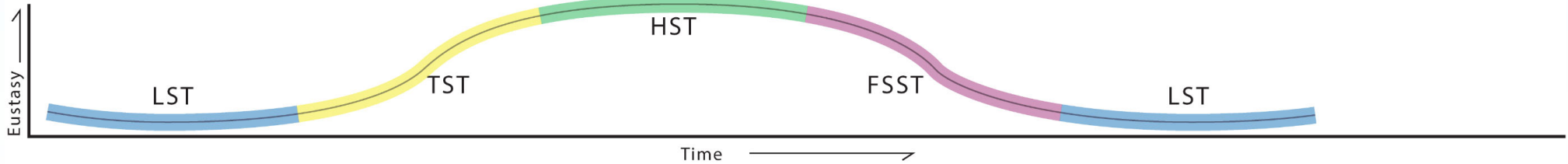
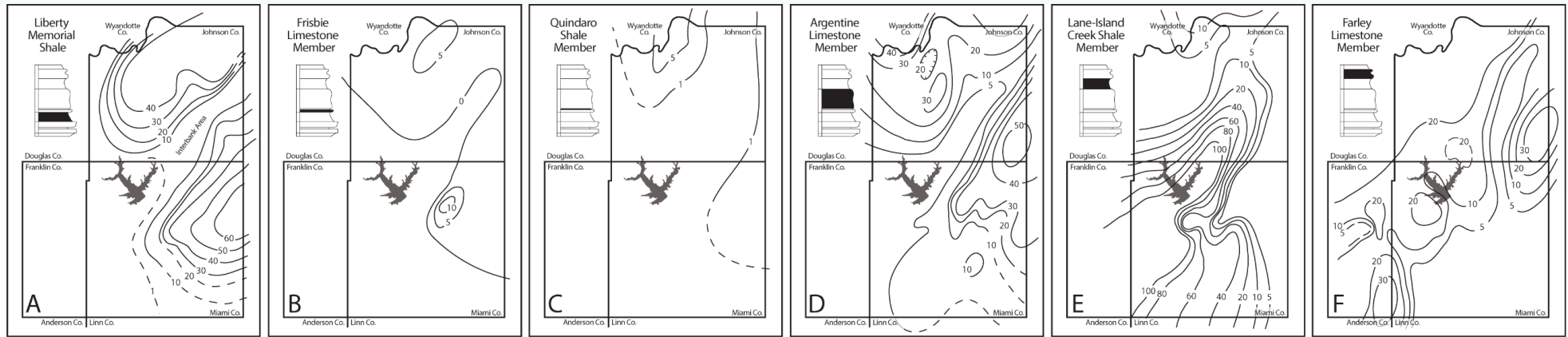
Previous Interpretation



Note: build-and-fill

(after Arvidson, 1990)

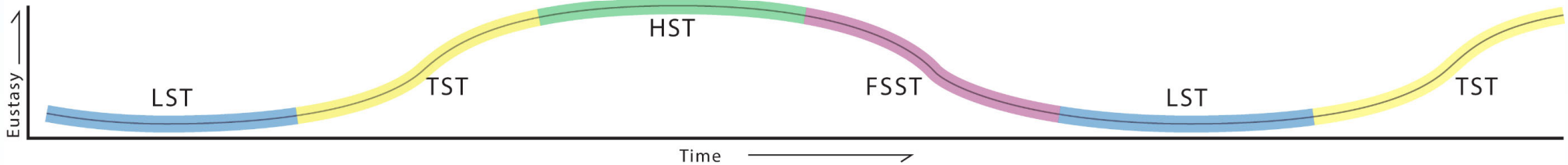
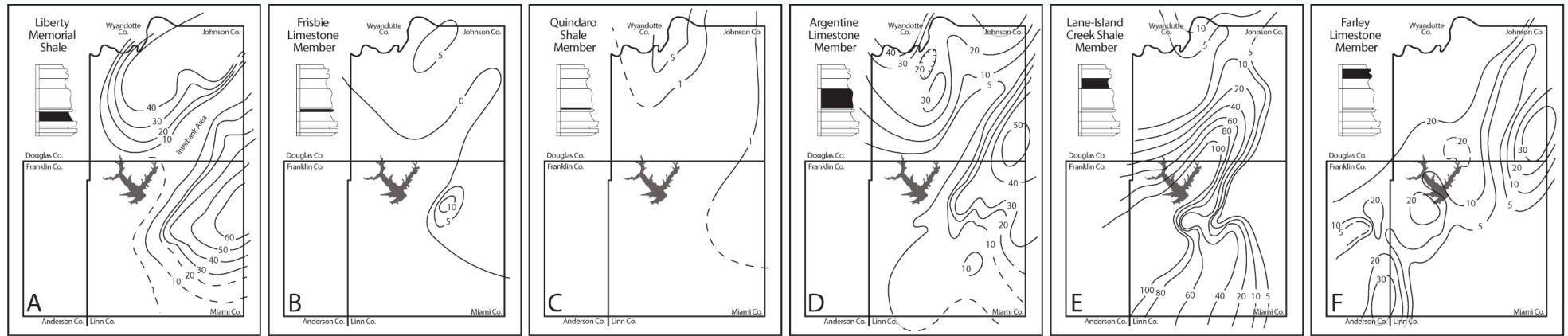
Previous Interpretation



Note: build-and-fill

(after Arvidson, 1990)

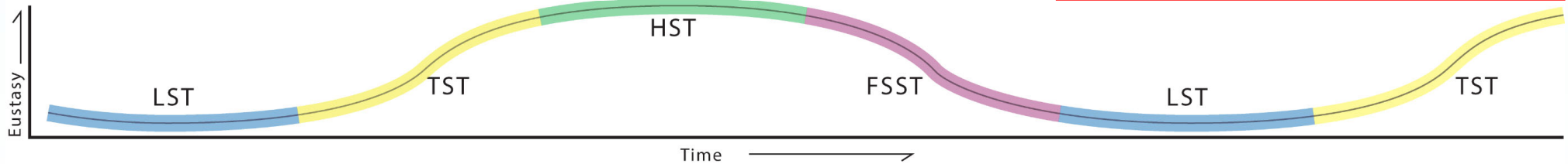
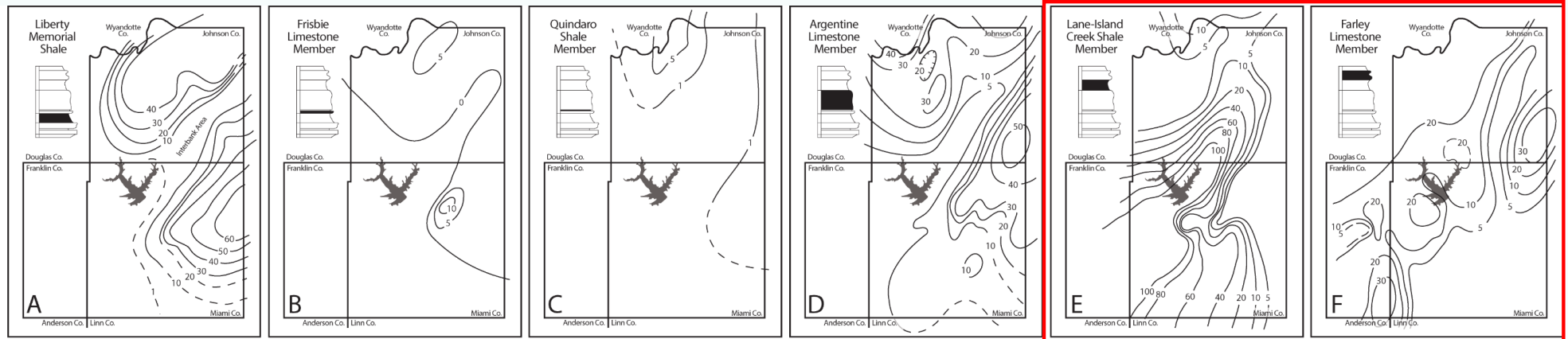
Previous Interpretation



Note: build-and-fill

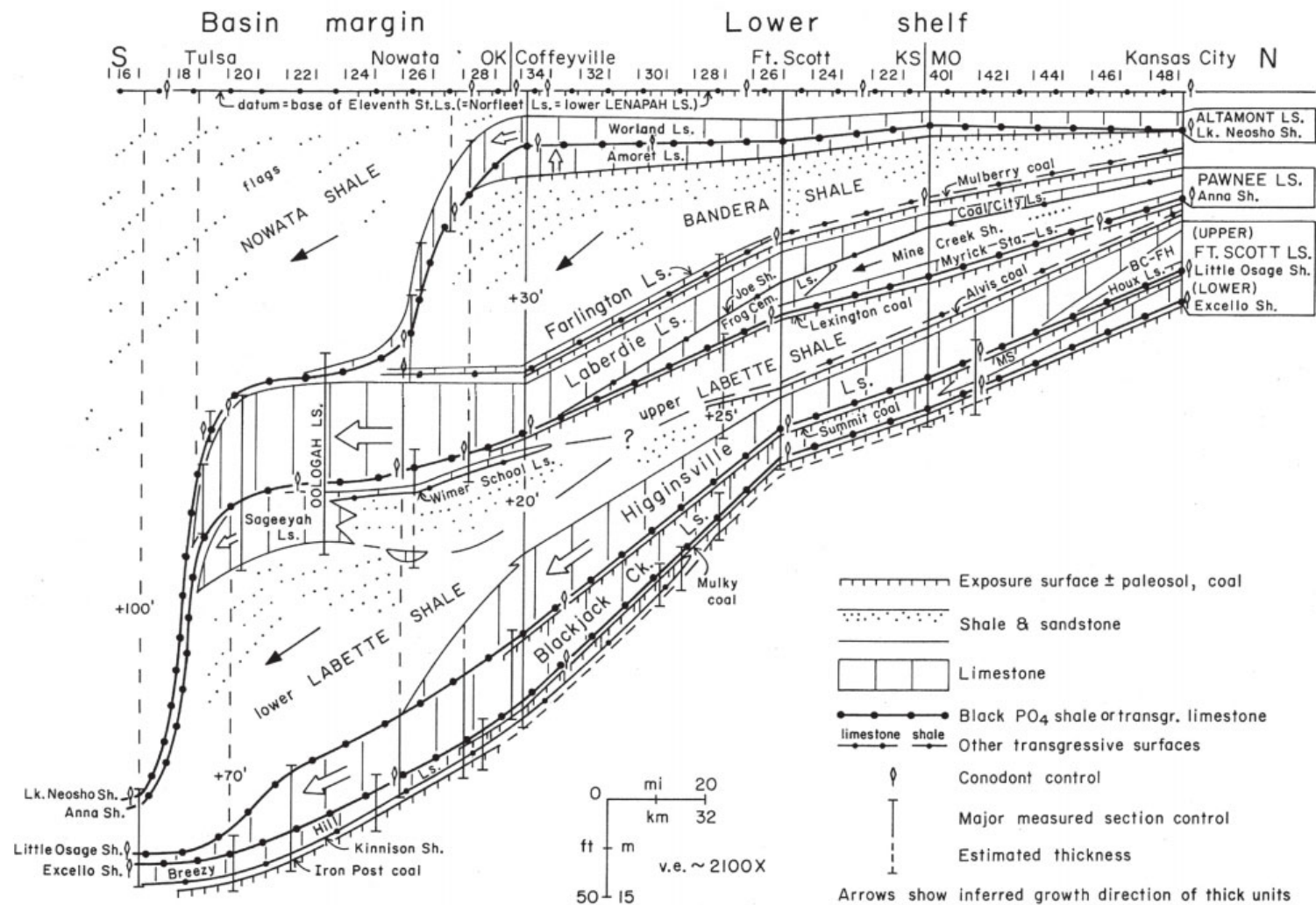
(after Arvidson, 1990)

Previous Interpretation



(after Arvidson, 1990)

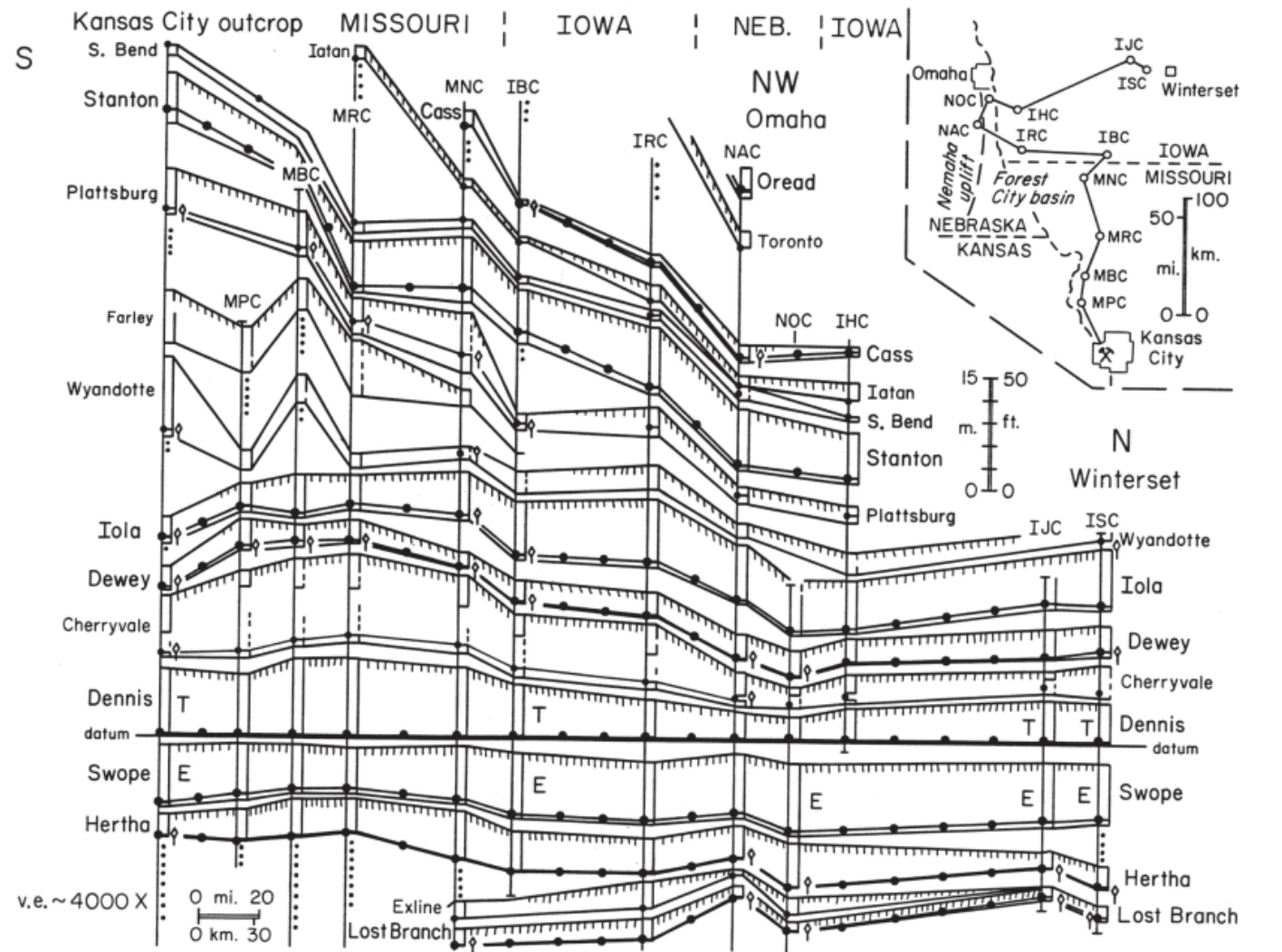
PLEASANTON GROUP	DESM. STAGE	MID. PENN.	BRONSON SUBGROUP	UPPER PENNSYLVANIAN SERIES
			LINN SUBGROUP	
			KANSAS CITY GROUP	
			ZARAH SUBGROUP	
LANSING GROUP				



TEXT-FIGURE 11
Correlation cross-section of lower and middle Marmaton (**upper Desmoinesian**) units and cyclothems from Kansas City (at roughly middle to lower shelf boundary), across lower shelf, to basin margin in Tulsa area of Oklahoma (updated from Heckel 2002, fig. 5). Cyclothems span interval from top of exposure surface upward to top of next exposure surface. BC-FH = Blackwater Creek Shale-Flint Hill Sandstone unit of Missouri.

(Heckel, 2013)

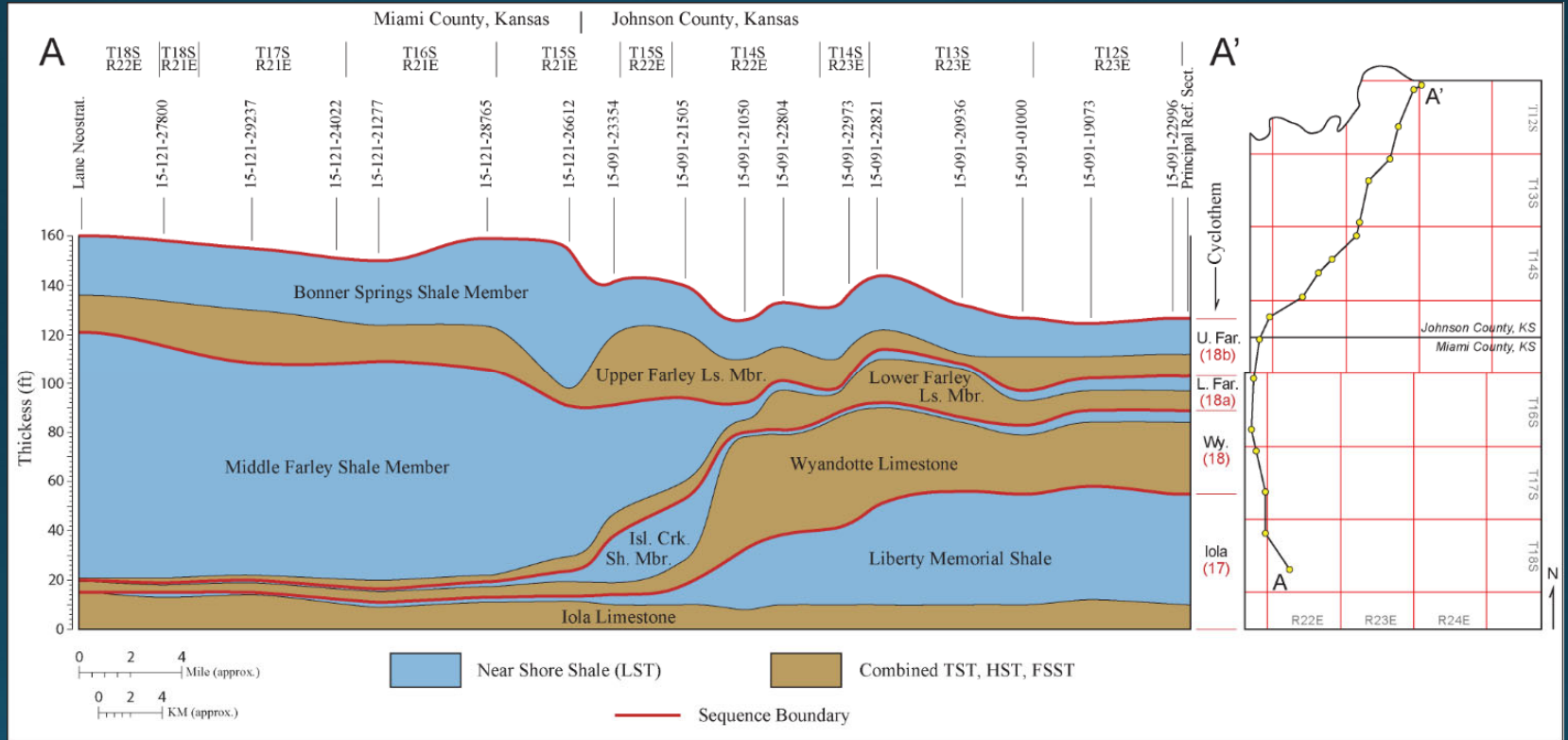
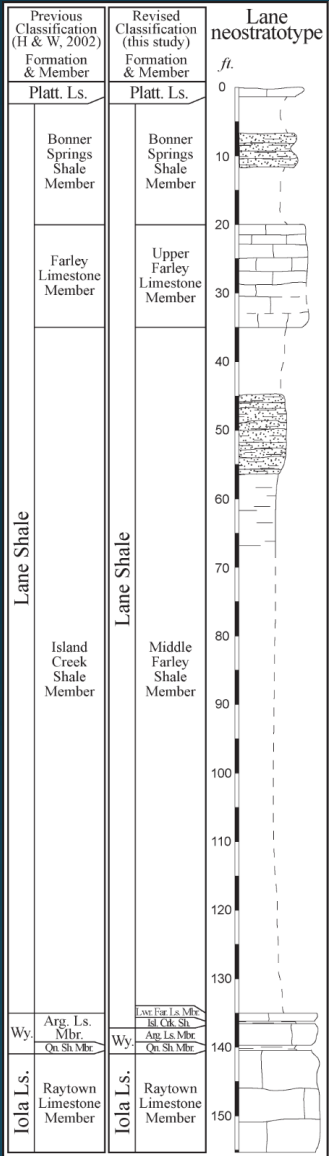
PLEASANTON GROUP	LANSING GROUP
BRONSON SUBGROUP	
LINN SUBGROUP	ZARAH SUBGROUP
KANSAS CITY GROUP	
DESM. STAGE	UPPER PENNSYLVANIAN SERIES
MID. PENN.	



TEXT-FIGURE 14

Correlation cross-section of **Missourian Stage** (= base of Exline to base of Cass) cyclothem in type region from Kansas City to Iowa, a mid-shelf position on northern shelf (updated from Heckel 1994, 2002). Lines with spots show condensed intervals; hachured lines show exposure surfaces; tailed diamond symbols show conodont control; capital letters show fusulinid control: E = *Eowaeringella*, T = first triticitids.

Let's quickly resolve the sediment sourcing



This adjustment affects the Lane Neostatotype

Outline

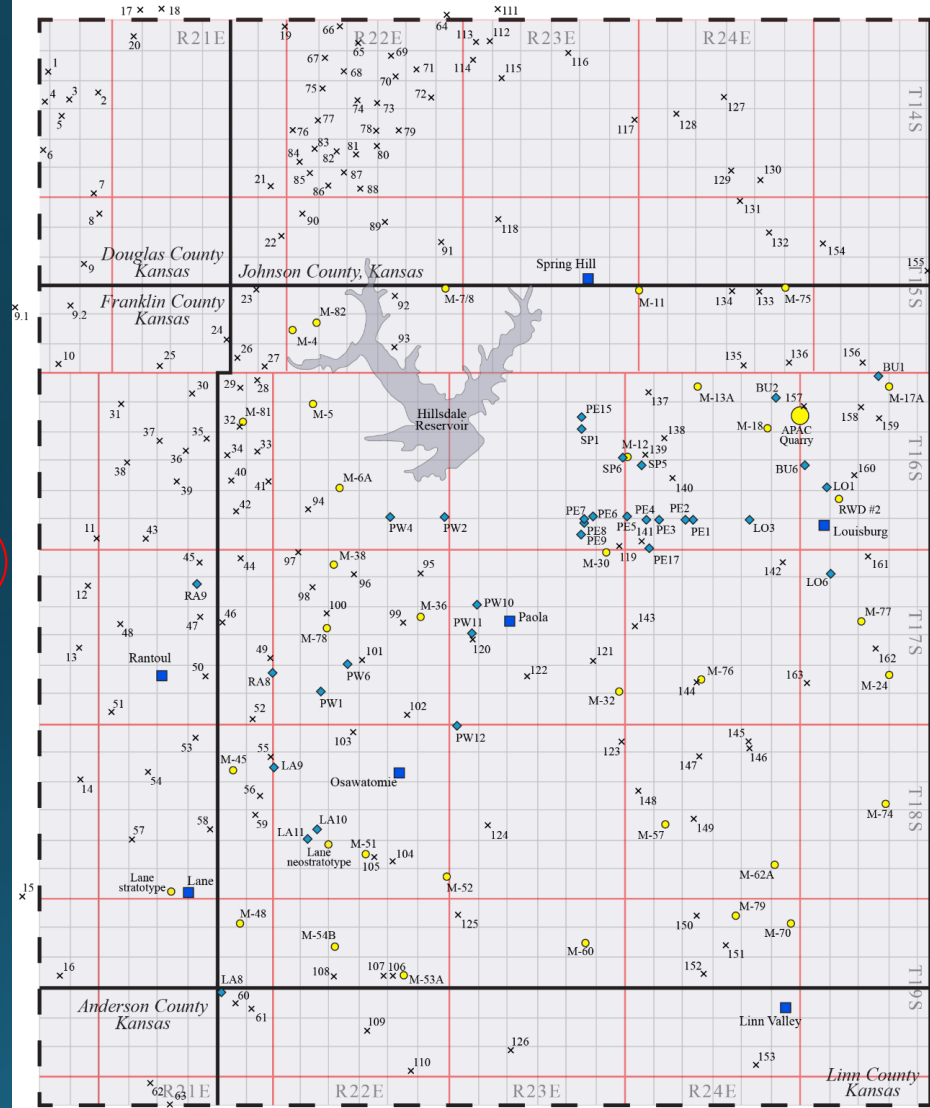
- 1) Paleogeography; Present Nomenclature; Previous Interpretation as of 1990 and the stratigraphic questions that arose with that research
- 2) **New depositional interpretation and new unit identification**
- 3) Implications of this research and recommendations for the future.

To the maps!

Green is thin
Brown/white is thick

- Dashed contour lines indicate no data within 0.5 miles
- Farley Limestone Mbr. is divided into Lower, Middle, and Upper units

Data Localities, Miami County, NE Kansas

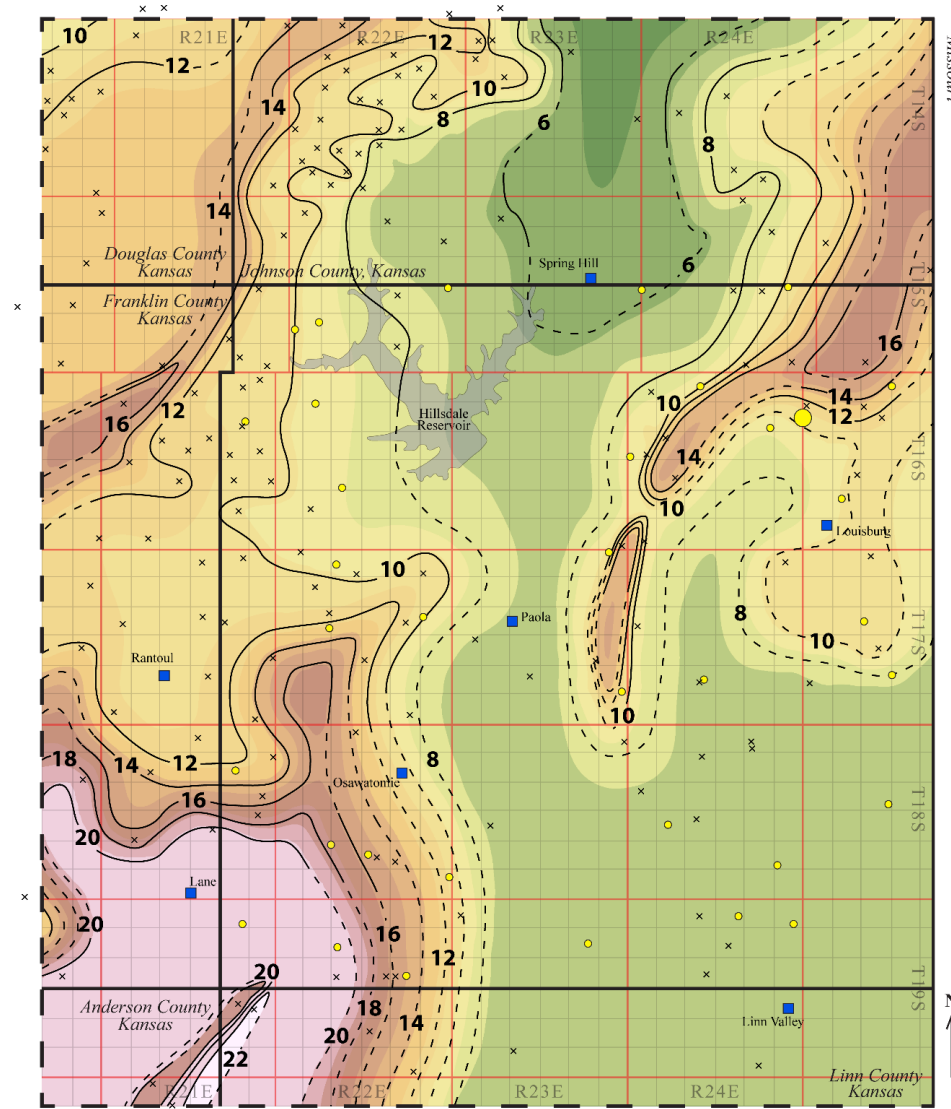


x Geophysical Logs ■ Towns ◆ (Arvidson, 1990) ● Core / Outcrop ● APAC Quarry

MISSOURIAN STAGE			
KANSAS CITY GROUP	ZARAH SUBGROUP	SOUTH BEND LS.	Little Kaw Ls. Mbr.
		LANSEING GROUP	
LANSEING GROUP	STANTON LS.	Stoner Ls. Mbr.	
		Eudora Sh. Mbr.	
		Captain Creek Ls. Mbr.	
VILAS SH.			
LANSEING GROUP	PLATTSBURG LS.	Spring Hill Ls. Mbr.	
		Hickory Creek Sh. Mbr.	
		Merriam Ls. Mbr.	
LANSEING GROUP	LANE SH.	Bonner Springs Sh. Mbr.	
		Farley Ls. Mbr.	
		Island Creek Sh. Mbr.	
LANSEING GROUP	WYANDOTTE LS.	Argentine Ls. Mbr.	
		Quindaro Sh. Mbr.	
		Frisbie Ls. Mbr.	
LIBERTY MEMORIAL SHALE			
LANSEING GROUP	IOLA LS.	Raytown Ls. Mbr.	
		Muncie Creek Sh. Mbr.	
		Paola Ls. Mbr.	
LIINN	CHANUTE SH.	Cottage Grove Ss. Mbr.	
		Noxie Ss. Mbr.	

(modified from Heckel & Watney, 2002)

Iola Limestone, Miami County, NE Kansas



- mounding in southwest
- moderate mounding in northeast and northwest
- aggradation largely associated with the Raytown Limestone Member (FSST)

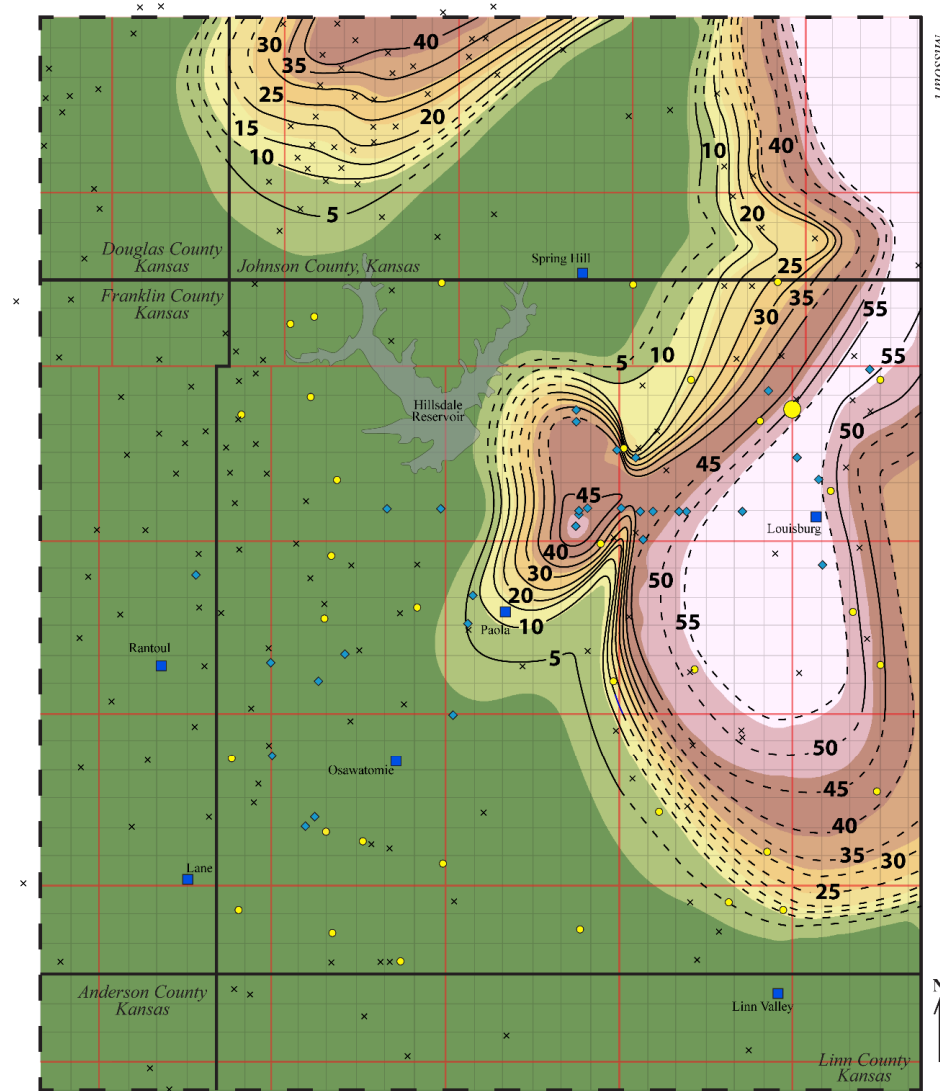
× Geophysical Logs ■ Towns ● Core / Outcrop ● APAC Quarry

NEW CLASSIFICATION for KANSAS (Heckel and Watney, 2002)

MISSOURIAN STAGE	LANSING GROUP	SOUTH BEND LS.	Little Kaw Ls. Mbr.
		ROCK LAKE SHALE	
		STANTON LS.	Stoner Ls. Mbr.
			Eudora Sh. Mbr.
	Captain Creek Ls. Mbr.		
	VILAS SH.		
	PLATTSBURG LS.	Spring Hill Ls. Mbr.	
		Hickory Creek Sh. Mbr.	
		Merriam Ls. Mbr.	
	LANE SH.	Bonner Springs Sh. Mbr.	
		Farley Ls. Mbr.	
		Island Creek Sh. Mbr.	
	WYANDOTTE LS.	Argentine Ls. Mbr.	
		Quindaro Sh. Mbr.	
Frisbie Ls. Mbr.			
LIBERTY MEMORIAL SHALE			
KANSAS CITY GROUP	ZARAH SUBGROUP	IOLA LS.	Raytown Ls. Mbr.
		Muncie Creek Sh. Mbr.	
		Paola Ls. Mbr.	
LINN	CHANUTE SH.	Cottage Grove Ss. Mbr.	
		Noxie Ss. Mbr.	

(modified from Heckel & Watney, 2002)

Liberty Memorial Shale, Miami County, NE Kansas



- sediment source from the northeast
- lobate geometry
- small fan at inlet of underlying Iola Limestone

× Geophysical Logs ■ Towns ◆ (Arvidson, 1990) ● Core / Outcrop ● APAC Quarry

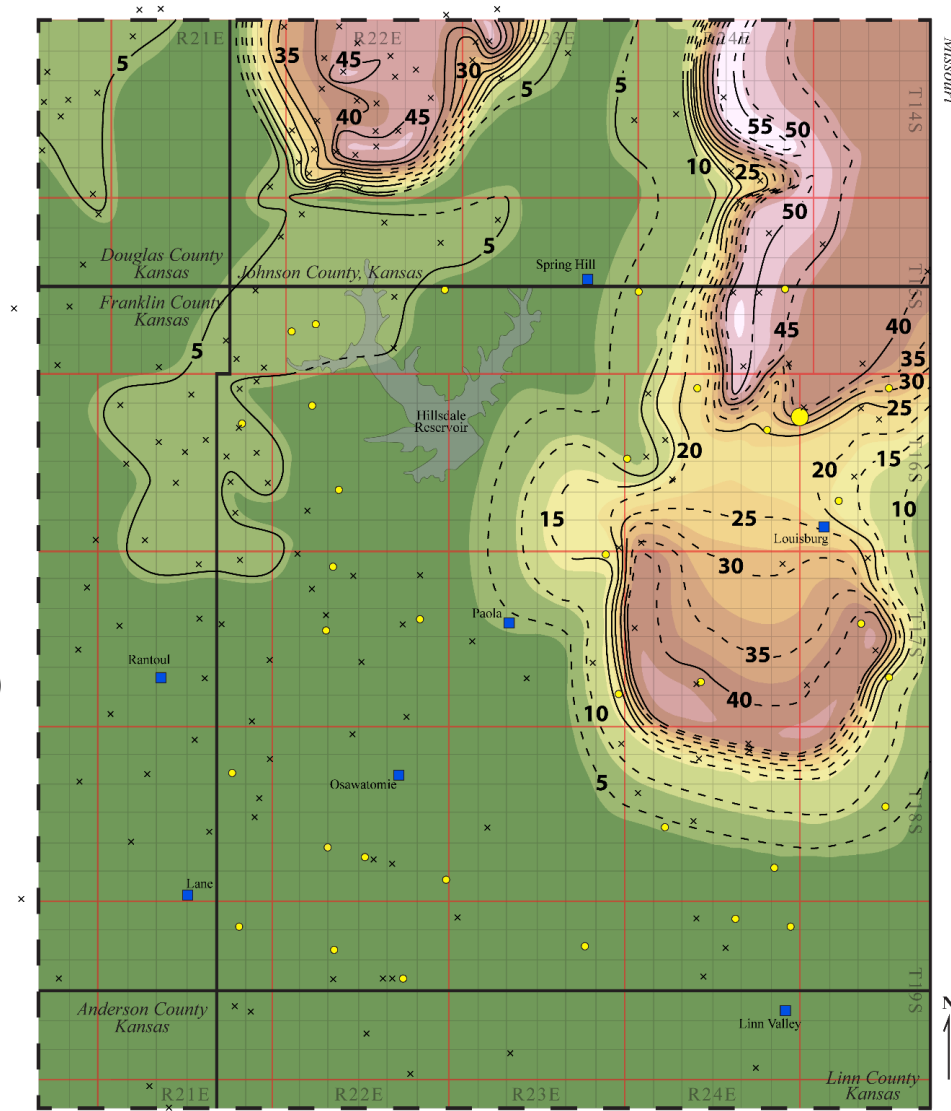
NEW CLASSIFICATION for KANSAS (Heckel and Watney, 2002)

MISSOURIAN STAGE	LANSING GROUP	SOUTH BEND LS.	Little Kaw Ls. Mbr.
		ROCK LAKE SHALE	
		STANTON LS.	Stoner Ls. Mbr.
			Eudora Sh. Mbr.
	Captain Creek Ls. Mbr.		
	VILAS SH.		
	PLATTSBURG LS.	Spring Hill Ls. Mbr.	
		Hickory Creek Sh. Mbr.	
		Merriam Ls. Mbr.	
	LANE SH.	Bonner Springs Sh. Mbr.	
		Farley Ls. Mbr.	
		Island Creek Sh. Mbr.	
		Argentine Ls. Mbr.	
	WYANDOTTE LS.	Quindaro Sh. Mbr.	
Frisbie Ls. Mbr.			
LIBERTY MEMORIAL SHALE			
IOLA LS.	Raytown Ls. Mbr.		
	Muncie Creek Sh. Mbr.		
	Paola Ls. Mbr.		
CHANUTE SH.	Cottage Grove Ss. Mbr.		
	Noxie Ss. Mbr.		

(modified from Heckel & Watney, 2002)

Wyandotte Limestone, Miami County, NE Kansas

- aggradation on bathymetric highs generated by underlying Liberty Memorial Shale
- aggradation largely associated with Argentine Limestone Member (FSST)



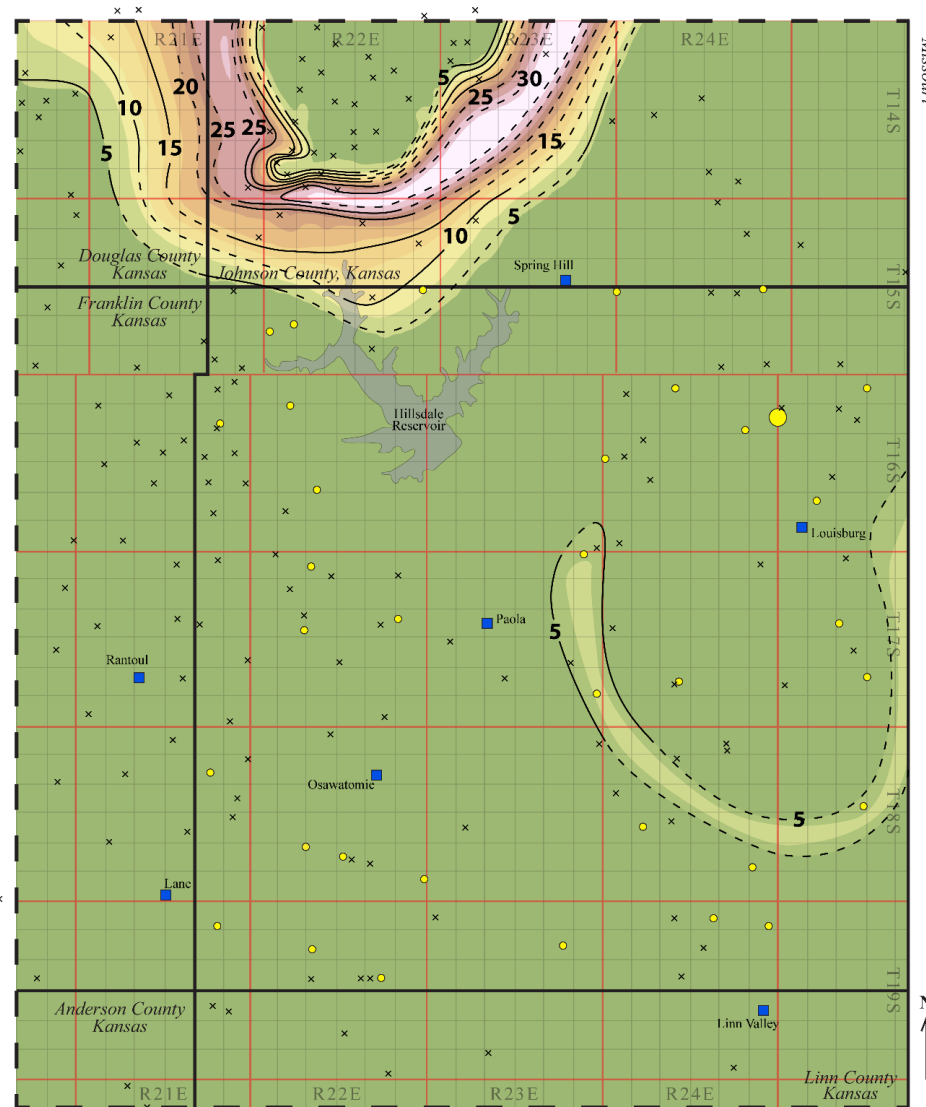
x Geophysical Logs ■ Towns ● Core / Outcrop ● APAC Quarry

NEW CLASSIFICATION for KANSAS (Heckel and Watney, 2002)

MISSOURIAN STAGE	LANSING GROUP	SOUTH BEND LS.	Little Kaw Ls. Mbr.
		ROCK LAKE SHALE	
	STANTON LS.	Stoner Ls. Mbr.	
		Eudora Sh. Mbr.	
		Captain Creek Ls. Mbr.	
	VILAS SH.		
	PLATTSBURG LS.	Spring Hill Ls. Mbr.	
		Hickory Creek Sh. Mbr.	
		Merriam Ls. Mbr.	
	LANE SH.	Bonner Springs Sh. Mbr.	
		Farley Ls. Mbr.	
	WYANDOTTE LS.	Island Creek Sh. Mbr.	
		Argentine Ls. Mbr.	
Quindaro Sh. Mbr.			
LIBERTY MEMORIAL SHALE	Frisbie Ls. Mbr.		
	LIBERTY MEMORIAL SHALE		
	IOLA LS.	Raytown Ls. Mbr.	
Muncie Creek Sh. Mbr.			
Paola Ls. Mbr.			
CHANUTE SH.	Cottage Grove Ss. Mbr.		
	Noxie Ss. Mbr.		

(modified from Heckel & Watney, 2002)

Island Creek Shale, Miami County, NE Kansas



× Geophysical Logs ■ Towns ● Core / Outcrop ● APAC Quarry

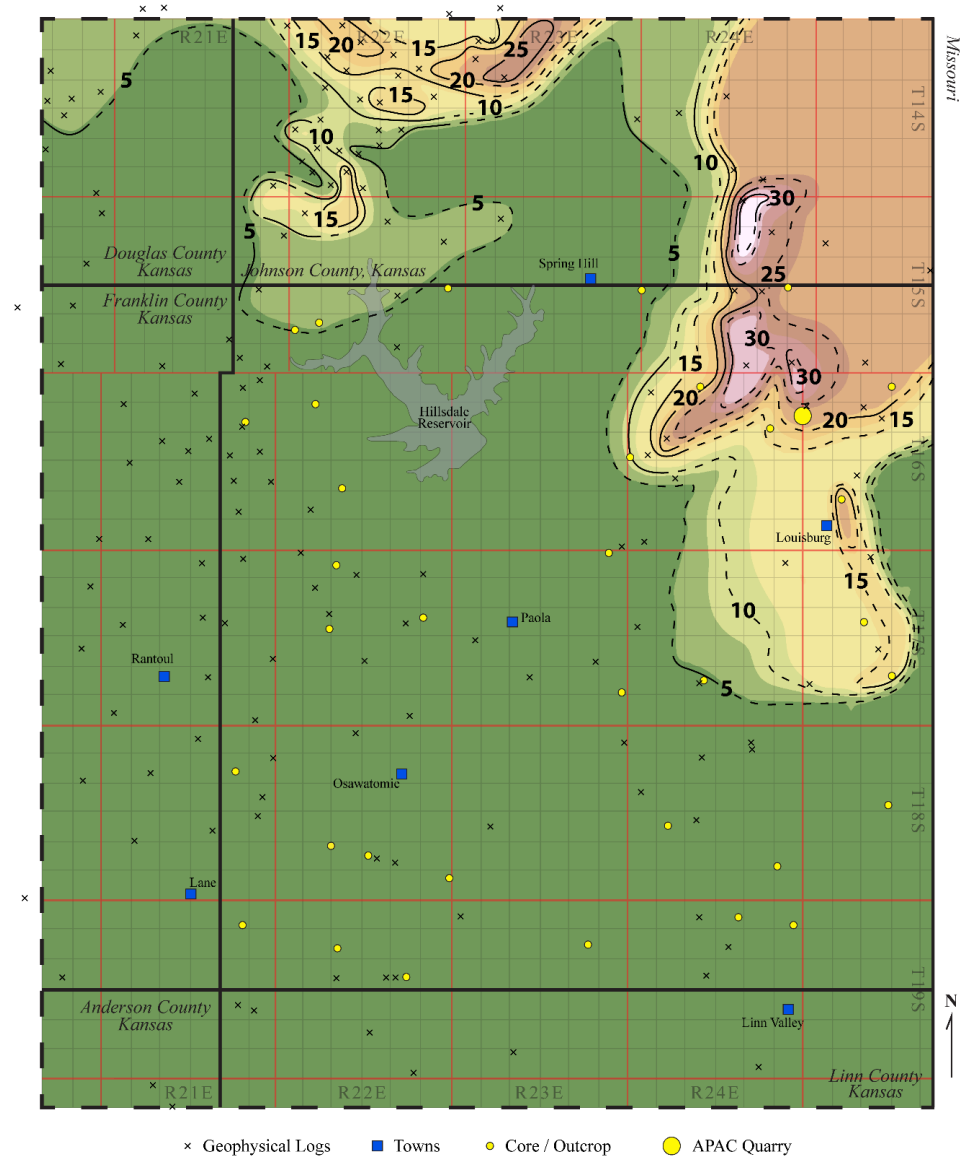
- deposition largely limited to peripheral edges of underlying Wyandotte mound
- top of Wyandotte described as skeletal hash and grainstone
 - suggests mound was above fair-wave base
 - shale swept clean

NEW CLASSIFICATION for KANSAS (Heckel and Watney, 2002)

MISSOURIAN STAGE	LANSING GROUP	SOUTH BEND LS.	Little Kaw Ls. Mbr.	
		ROCK LAKE SHALE		
		STANTON LS.	Stoner Ls. Mbr.	
			Eudora Sh. Mbr.	
	Captain Creek Ls. Mbr.			
	VILAS SH.			
	PLATTSBURG LS.	Spring Hill Ls. Mbr.		
		Hickory Creek Sh. Mbr.		
		Merriam Ls. Mbr.		
	KANSAS CITY GROUP	ZARAH SUBGROUP	LANE SH.	Bonner Springs Sh. Mbr.
			Island Creek Sh. Mbr.	Farley Ls. Mbr.
	WYANDOTTE LS.	Argentine Ls. Mbr.		
		Quindaro Sh. Mbr.		
Frisbie Ls. Mbr.				
LIBERTY MEMORIAL SHALE				
IOLA LS.	Raytown Ls. Mbr.			
	Muncie Creek Sh. Mbr.			
CHANUTE SH.	Paola Ls. Mbr.			
	Cottage Grove Ss. Mbr.			
		Noxie Ss. Mbr.		

(modified from Heckel & Watney, 2002)

Lower Farley Limestone, Miami County, NE Kansas



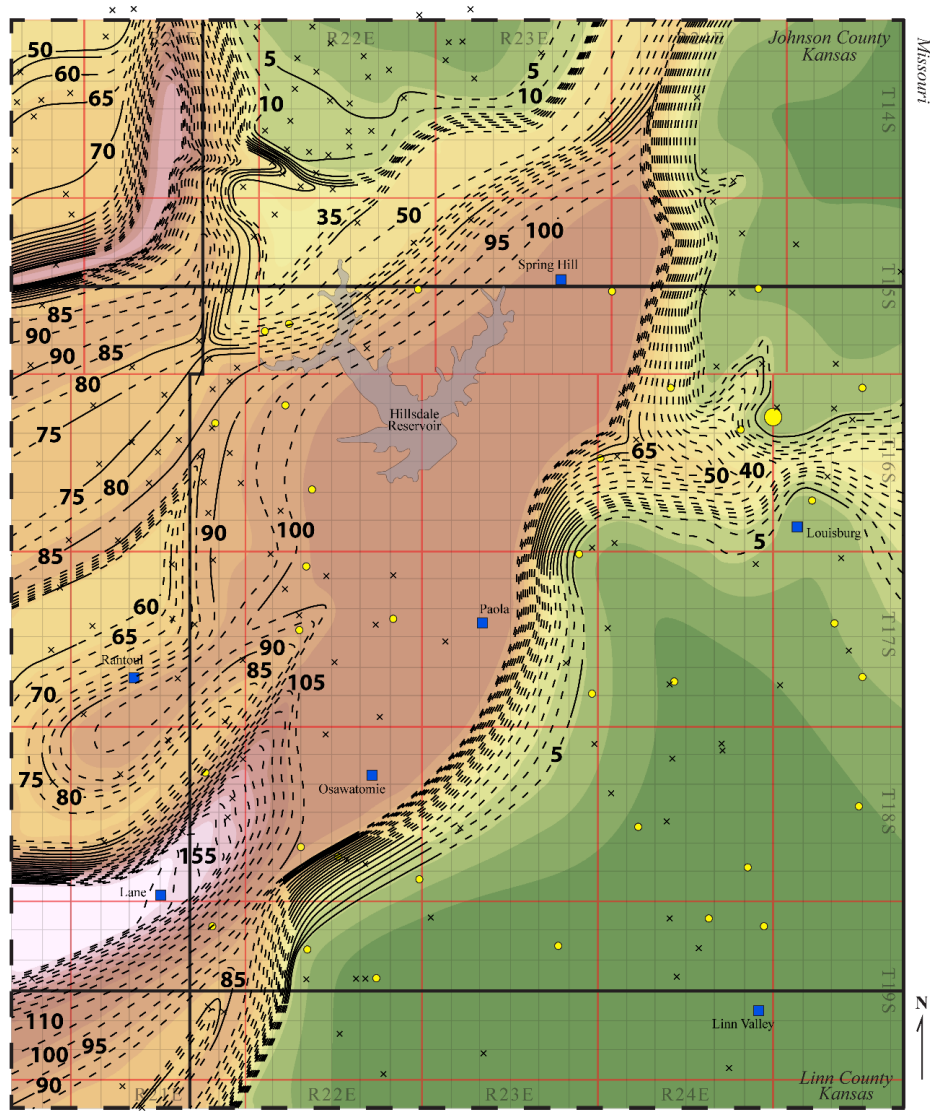
- aggradation on top of underlying bathymetric highs
- meteoric alteration

NEW CLASSIFICATION for KANSAS (Heckel and Watney, 2002)

MISSOURIAN STAGE	LANSING GROUP	SOUTH BEND LS.	Little Kaw Ls. Mbr.
		ROCK LAKE SHALE	
		STANTON LS.	Stoner Ls. Mbr. Eudora Sh. Mbr. Captain Creek Ls. Mbr.
	PLATTSBURG LS.	VILAS SH.	
		Spring Hill Ls. Mbr.	Hickory Creek Sh. Mbr.
		Merriam Ls. Mbr.	Bonner Springs Sh. Mbr.
		LANE SH.	Farley Ls. Mbr.
		Island Creek Sh. Mbr.	Argentine Ls. Mbr.
	WYANDOTTE LS.	Quindaro Sh. Mbr.	Frisbie Ls. Mbr.
		LIBERTY MEMORIAL SHALE	
		IOLA LS.	Raytown Ls. Mbr. Muncie Creek Sh. Mbr. Paola Ls. Mbr.
	CHANUTE SH.	Cottage Grove Ss. Mbr. Noxie Ss. Mbr.	

(modified from Heckel & Watney, 2002)

Middle Farley Shale, Miami County, NE Kansas



× Geophysical Logs ■ Towns ● Core / Outcrop ● APAC Quarry

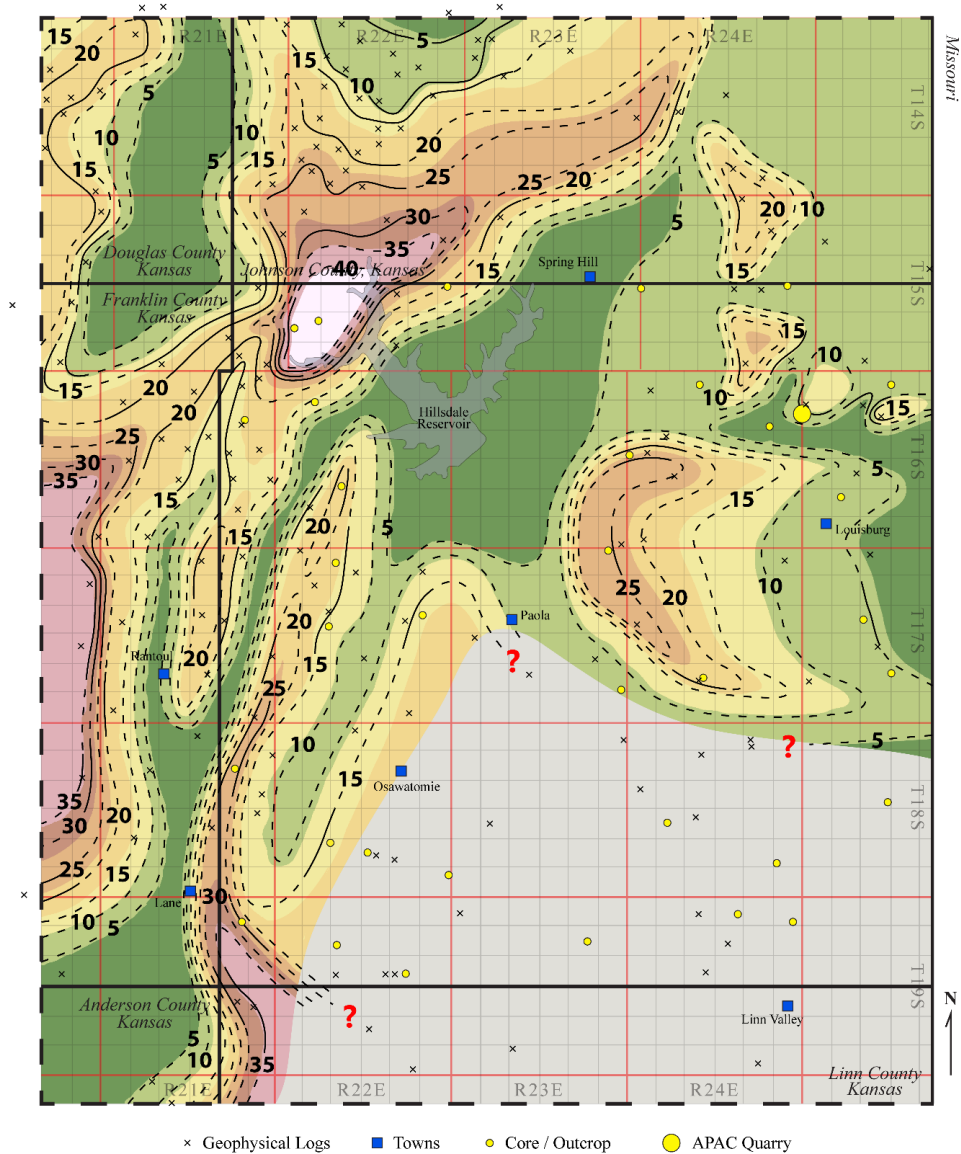
- large sediment influx and westward progradation
- incised with continued sea level regression
- exposure surfaces and coals in western Miami County
- structural faulting in southwest controlling unit deposition

NEW CLASSIFICATION for KANSAS (Heckel and Watney, 2002)

MISSOURIAN STAGE	KANSAS CITY GROUP	ZARAH SUBGROUP	SOUTH BEND LS.	Little Kaw Ls. Mbr.
			ROCK LAKE SHALE	
			STANTON LS.	Stoner Ls. Mbr.
				Eudora Sh. Mbr.
				Captain Creek Ls. Mbr.
			VILAS SH.	
	PLATTSBURG LS.	Spring Hill Ls. Mbr.		
		Hickory Creek Sh. Mbr.		
		Merriam Ls. Mbr.		
	LANE SH.	Bonner Springs Sh. Mbr.		
		Farley Ls. Mbr.		
		Island Creek Sh. Mbr.		
		Argentine Ls. Mbr.		
	WYANDOTTE LS.	Quindaro Sh. Mbr.		
Frisbie Ls. Mbr.				
LIBERTY MEMORIAL SHALE				
IOLA LS.	Raytown Ls. Mbr.			
	Muncie Creek Sh. Mbr.			
	Paola Ls. Mbr.			
CHANUTE SH.	Cottage Grove Ss. Mbr.			
	Noxie Ss. Mbr.			

(modified from Heckel & Watney, 2002)

Upper Farley Limestone, Miami County, NE Kansas



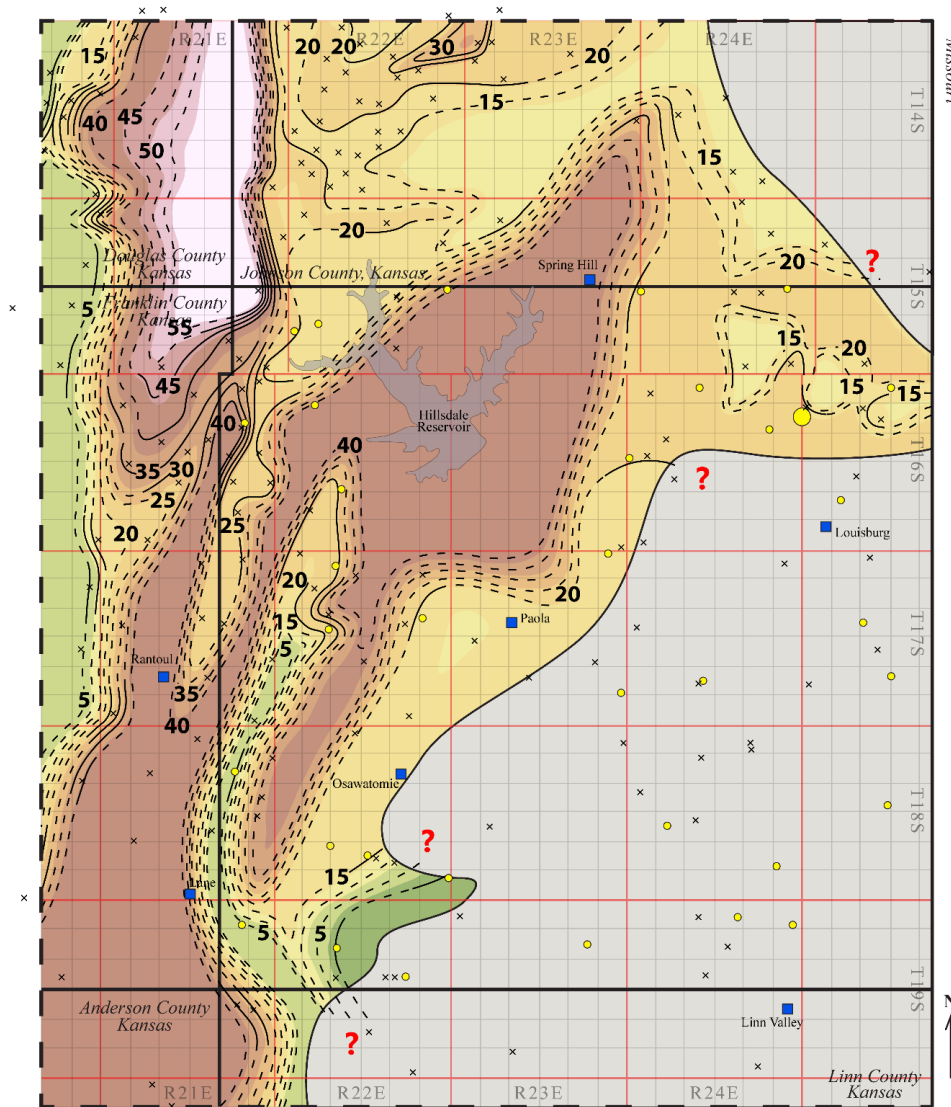
- site of aggradation moves to west
- meteoric alteration

NEW CLASSIFICATION for KANSAS (Heckel and Watney, 2002)

MISSOURIAN STAGE	LANSING GROUP	SOUTH BEND LS.	Little Kaw Ls. Mbr.
		ROCK LAKE SHALE	
		STANTON LS.	Stoner Ls. Mbr.
			Eudora Sh. Mbr.
			Captain Creek Ls. Mbr.
	VILAS SH.		
	PLATTSBURG LS.	Spring Hill Ls. Mbr.	
		Hickory Creek Sh. Mbr.	
		Merriam Ls. Mbr.	
		Bonner Springs Sh. Mbr.	
	LANE SH.	Farley Ls. Mbr.	
		Island Creek Sh. Mbr.	
		Argentine Ls. Mbr.	
WYANDOTTE LS.	Quindaro Sh. Mbr.		
	Frisbie Ls. Mbr.		
	LIBERTY MEMORIAL SHALE		
IOLA LS.	Raytown Ls. Mbr.		
	Muncie Creek Sh. Mbr.		
	Paola Ls. Mbr.		
CHANUTE SH.	Cottage Grove Ss. Mbr.		
	Noxie Ss. Mbr.		
KANSAS CITY GROUP			
ZARAH SUBGROUP			
LINN			

(modified from Heckel & Watney, 2002)

Bonner Springs Shale, Miami County, NE Kansas



- fills in bathymetric lows generated by upper Farley limestone member

NEW CLASSIFICATION for KANSAS (Heckel and Watney, 2002)

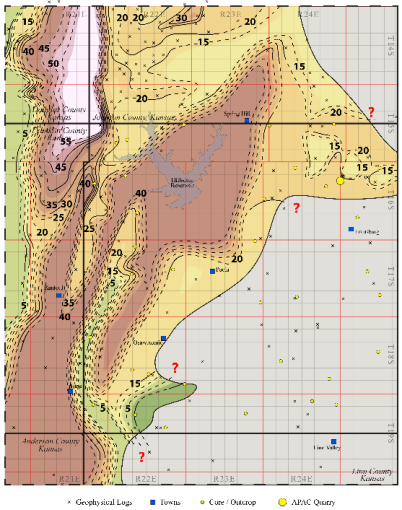
MISSOURIAN STAGE	LANSING GROUP	SOUTH BEND LS.	Little Kaw Ls. Mbr.
		ROCK LAKE SHALE	
		STANTON LS.	Stoner Ls. Mbr.
			Eudora Sh. Mbr.
	Captain Creek Ls. Mbr.		
	VILAS SH.		
	PLATTSBURG LS.	Spring Hill Ls. Mbr.	
		Hickory Creek Sh. Mbr.	
		Merriam Ls. Mbr.	
	KANSAS CITY GROUP	ZARAH SUBGROUP	Bonner Springs Sh. Mbr.
			LANE SH.
		WYANDOTTE LS.	Island Creek Sh. Mbr.
			Argentine Ls. Mbr.
	Quindaro Sh. Mbr.		
LIBERTY MEMORIAL SHALE			
LINN	IOLA LS.	Raytown Ls. Mbr.	
		Muncie Creek Sh. Mbr.	
	CHANUTE SH.	Cottage Grove Ss. Mbr.	
		Noxie Ss. Mbr.	

(modified from Heckel & Watney, 2002)

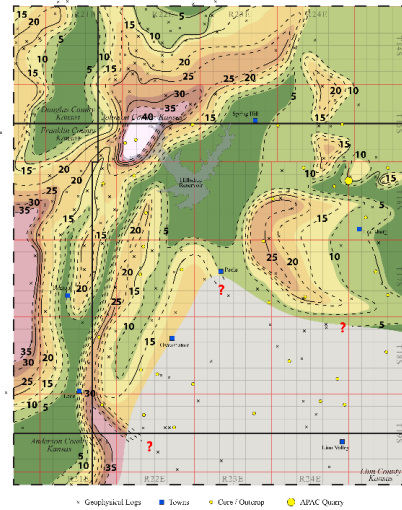
x Geophysical Logs ■ Towns ● Core / Outcrop ● APAC Quarry

All at once, now!

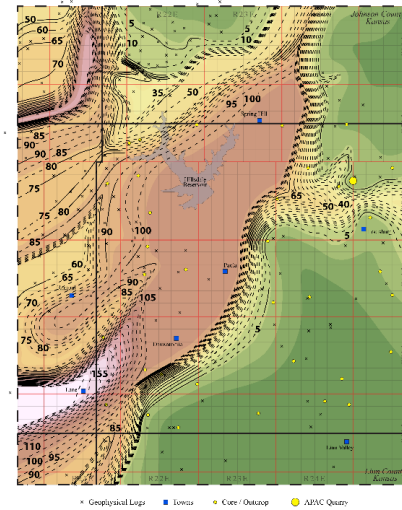
Bonner Springs Shale, Miami County, NE Kansas



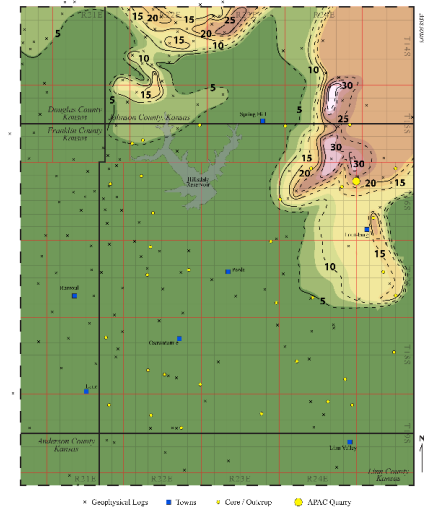
Upper Farley Limestone, Miami County, NE Kansas



Middle Farley Shale, Miami County, NE Kansas

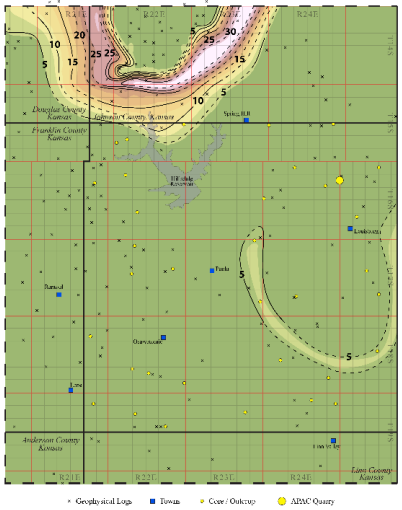


Lower Farley Limestone, Miami County, NE Kansas

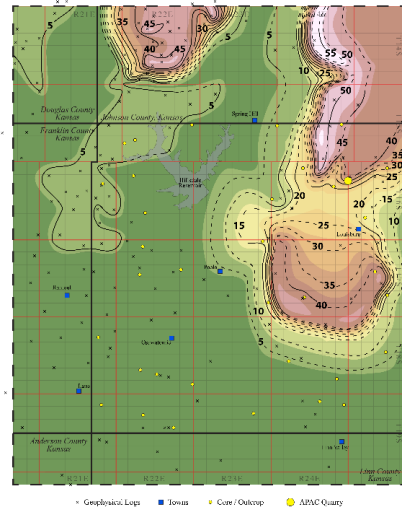


Predictable Pattern

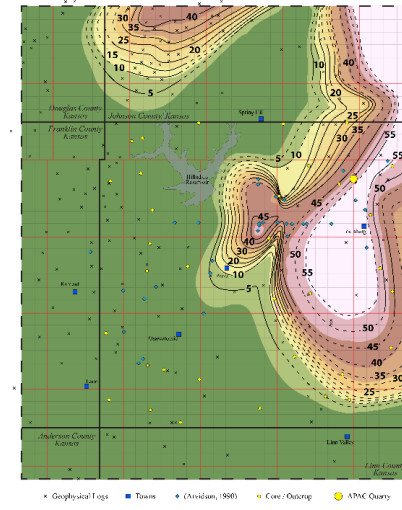
Island Creek Shale, Miami County, NE Kansas



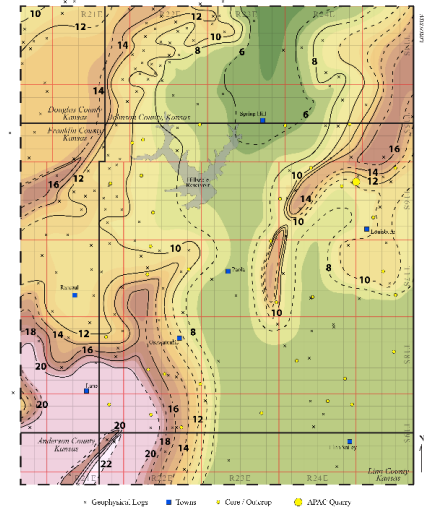
Wyandotte Limestone, Miami County, NE Kansas



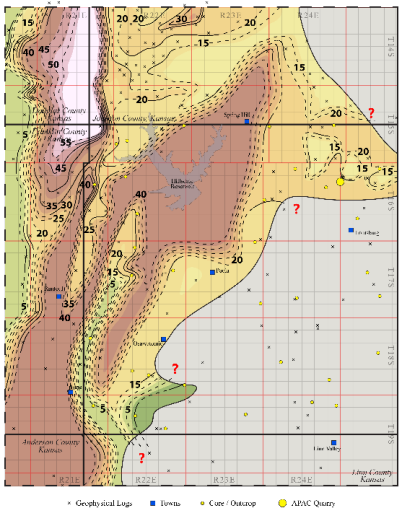
Liberty Memorial Shale, Miami County, NE Kansas



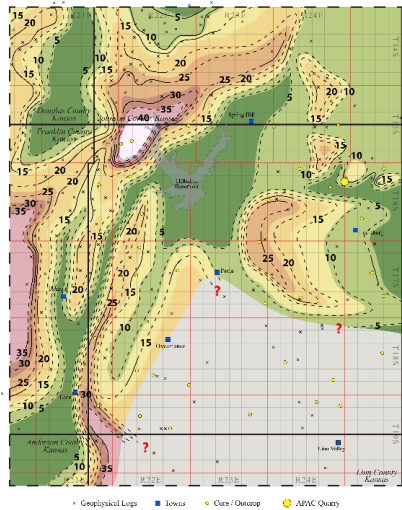
Iola Limestone, Miami County, NE Kansas



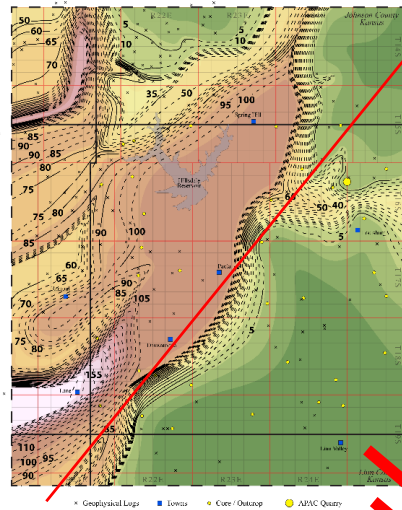
Bonner Springs Shale, Miami County, NE Kansas



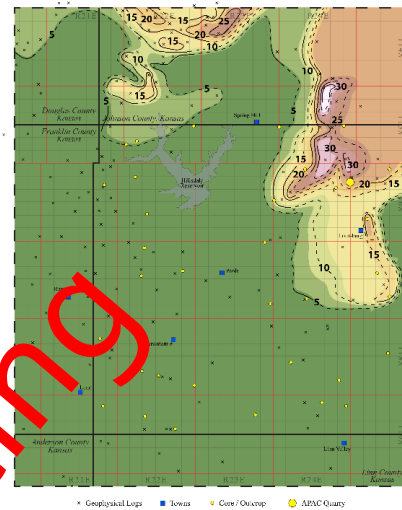
Upper Farley Limestone, Miami County, NE Kansas



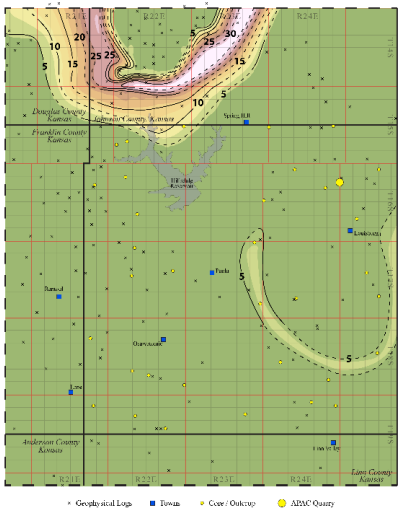
Middle Farley Shale, Miami County, NE Kansas



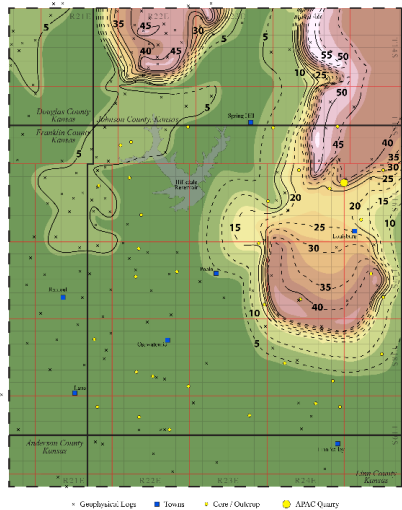
Lower Farley Limestone, Miami County, NE Kansas



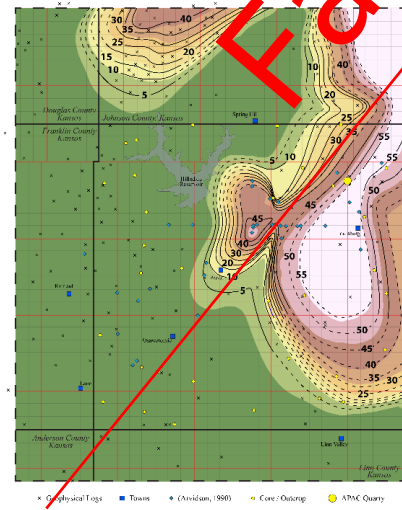
Island Creek Shale, Miami County, NE Kansas



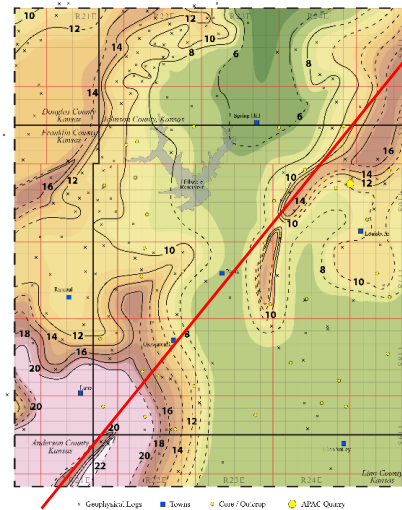
Wyandotte Limestone, Miami County, NE Kansas



Liberty Memorial Shale, Miami County, NE Kansas



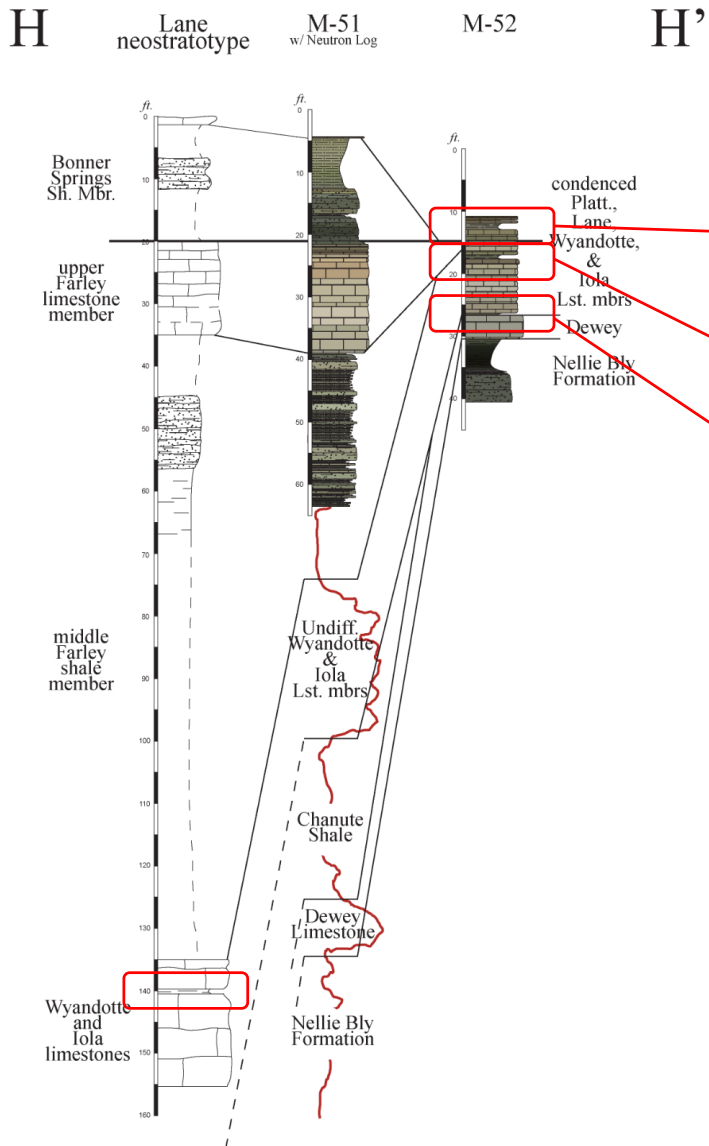
Iola Limestone, Miami County, NE Kansas



Predictable Pattern

Fracturing

Evidence for Faulting
vs.
Incision



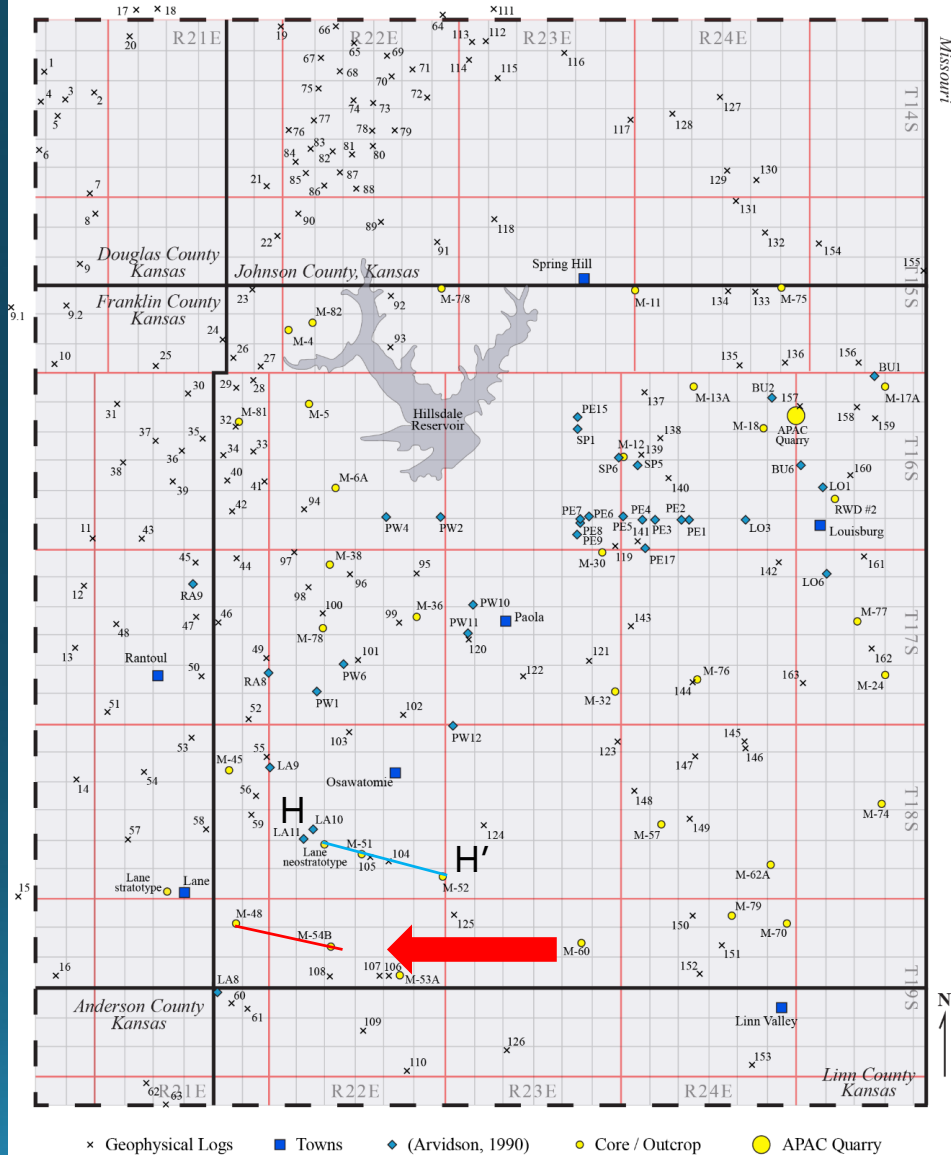
NEW CLASSIFICATION for KANSAS
(Heckel and Watney, 2002)

MISSOURIAN STAGE	LANING GROUP	SOUTH BEND LS.	Little Kaw Ls. Mbr.
		ROCK LAKE SHALE	
		STANTON LS.	Stoner Ls. Mbr.
			Eudora Sh. Mbr.
			Captain Creek Ls. Mbr.
	VILAS SH.		
	PLATTSBURG LS.	Spring Hill Ls. Mbr.	
	KANSAS CITY GROUP	ZARAH SUBGROUP	Hickory Creek Sh. Mbr.
			Merriam Ls. Mbr.
		LANE SH.	
Bonner Springs Sh. Mbr.			
Farley Ls. Mbr.			
LINN	WYANDOTTE LS.	Island Creek Sh. Mbr.	
		Argentine Ls. Mbr.	
	LIBERTY MEMORIAL SHALE		
	IOLA LS.	Quindaro Sh. Mbr.	
		Frisbie Ls. Mbr.	
CHANUTE SH.	Raytown Ls. Mbr.		
	Muncie Creek Sh. Mbr.		
	Paola Ls. Mbr.		
	Cottage Grove Ss. Mbr.		
	Noxie Ss. Mbr.		

(modified from Heckel & Watney, 2002)

- near-shores absent
- high-stands present

Data Localities, Miami County, NE Kansas



Formations Studied



Limestone Dominated



Shale Dominated

map represents the top of the Hushpuckney Shale (m-AMSL)

OLD CLASSIFICATION (Zeller, editor, 1968)		NEW CLASSIFICATION for KANSAS (Heckel and Watney, 2002)	
		south	north
LANSING GROUP	STANTON L.S.	South Bend Ls. Mbr.	Little Kaw Ls. Mbr.
		Rock Lake Sh. Mbr.	ROCK LAKE SH.
		Stoner Ls. Mbr.	3 beds Stoner Ls. Mbr.
		Eudora Sh. Mbr.	Eudora Sh. Mbr.
		Captain Creek Ls. Mbr.	2 beds Captain Creek Ls. Mbr.
	VILAS SH.	VILAS SH.	
	PLATTSBURG L.S.	Spring Hill Ls. Mbr.	Spring Hill Ls. Mbr.
		Hickory Creek Sh. Mbr.	Hickory Creek Sh. Mbr.
		Merriam Ls. Mbr.	Merriam Ls. Mbr.
	MISSOURIAN STAGE	ZARAH SUBGROUP	BONNER SPRINGS SH.
Farley Ls. Mbr.			Farley Ls. Mbr.
Island Creek Sh. Mbr.			Island Creek Sh. Mbr.
Argentine Ls. Mbr.			Argentine Limestone Mbr.
Quindaro Sh. Mbr.			Quindaro Shale Mbr.
Frisbie Ls. Mbr.			Frisbie Limestone Mbr.
LANE SH.		LIBERTY MEMORIAL SH.	
IOLA L.S.		Raytown Ls. Mbr.	Raytown Limestone Mbr.
		Muncie Creek Sh. Mbr.	Muncie Creek Shale Mbr.
		Paola Ls. Mbr.	Paola Limestone Mbr.
CHANUTE SH.	Cottage Grove Ss. Mbr.	Cottage Grove ss. bed	
	Noxie Ss. Mbr.	Thayer coal bed	
DRUM L.S.	Corbin City Ls. Mbr.	Cement City Ls. Mbr.	
	Dewey Ls. Mbr.	Quivira Sh. Mbr.	
CHERRYVALE SH.	Quivira Sh. Mbr.	NELLIE BLY FORMATION	
	Westerville Ls. Mbr.	Drum Ls. Mbr.	
	Wea Sh. Mbr.	Wea Sh. Mbr.	
	Block Ls. Mbr.	Block Ls. Mbr.	
	Fontana Sh. Mbr.	Fontana Sh. Mbr.	
DENNIS L.S.	Winterset Ls. Mbr.	Winterset Ls. Mbr.	
	Stark Sh. Mbr.	Stark Sh. Mbr.	
	Canville Ls. Mbr.	Canville Ls. Mbr.	
BRONSON SUBGROUP	GALESBURG SH.	Docks Creek Ss. Mbr.	
	SWOPE L.S.	Bethany Falls Ls. Mbr.	Bethany Falls Ls. Mbr.
		Hushpuckney Sh. Mbr.	Hushpuckney Sh. Mbr.
		Middle Creek Ls. Mbr.	Middle Creek Ls. Mbr.
	LADORE SH.	ELM BRANCH SH.	
HERTHA L.S.	Sniabar Ls. Mbr.	Mid. Ls. Mbr.	
	Mound City Sh. Mbr.	Mound City Sh. Mbr.	
	Critzer Ls. Mbr.	Guthrie Mountain Sh. Mbr.	
PLEASANTON GROUP	TACKET FORMATION	Critzer Ls. Mbr.	
	CHECKERBOARD LIMESTONE	Mantey Sh. Mbr.	
	SEMINOLE FORMATION	Exline Ls. Mbr.	
	Helper Ss. Mbr.	Helper Ss. Mbr.	

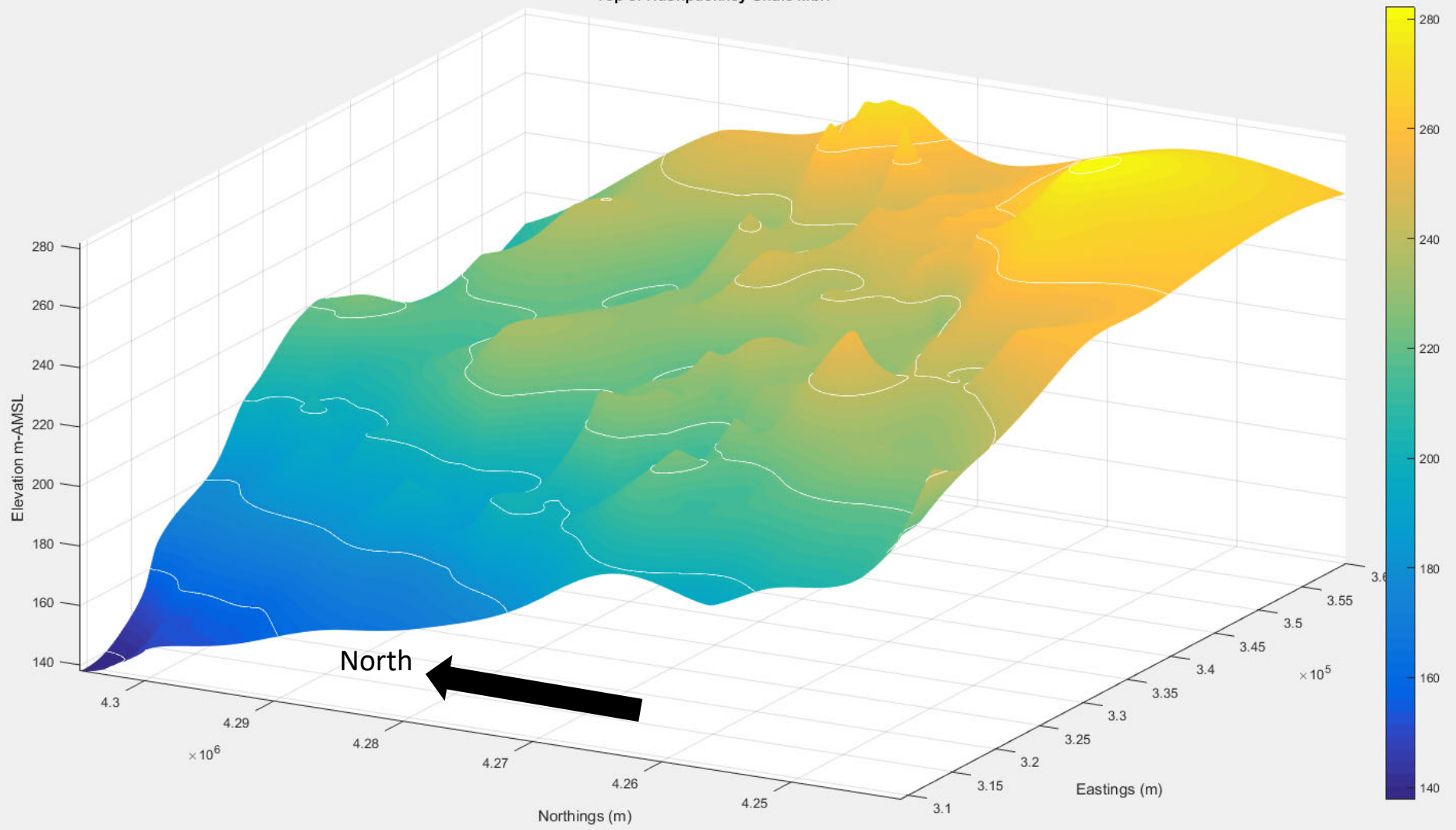
Focus of study

Onset of faulting w/ Block Ls.

Interpolation of Hushpuckney Sh.

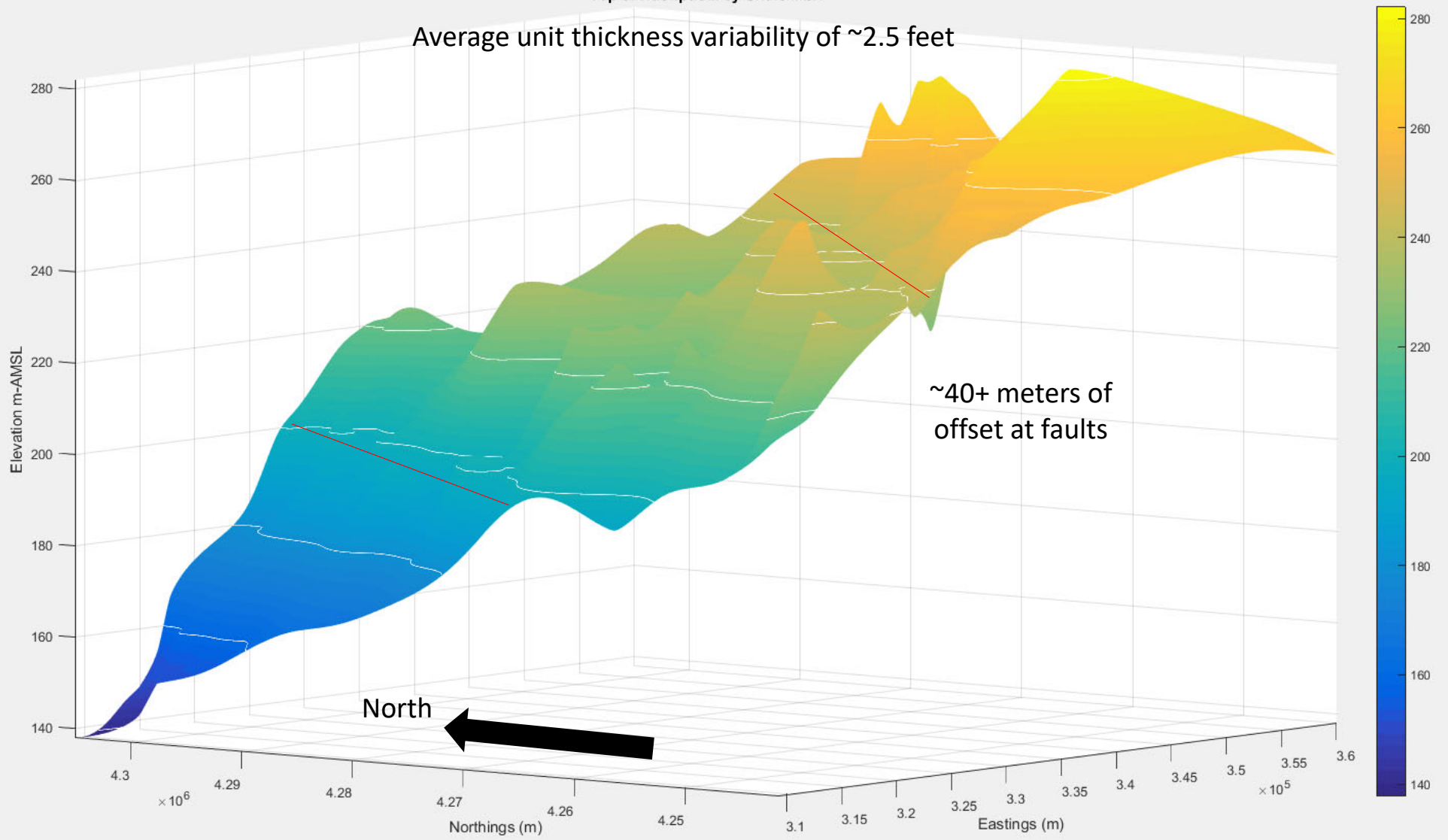
(after Heckel & Watney, 2002)

Top of Hushpuckney Shale Mbr.

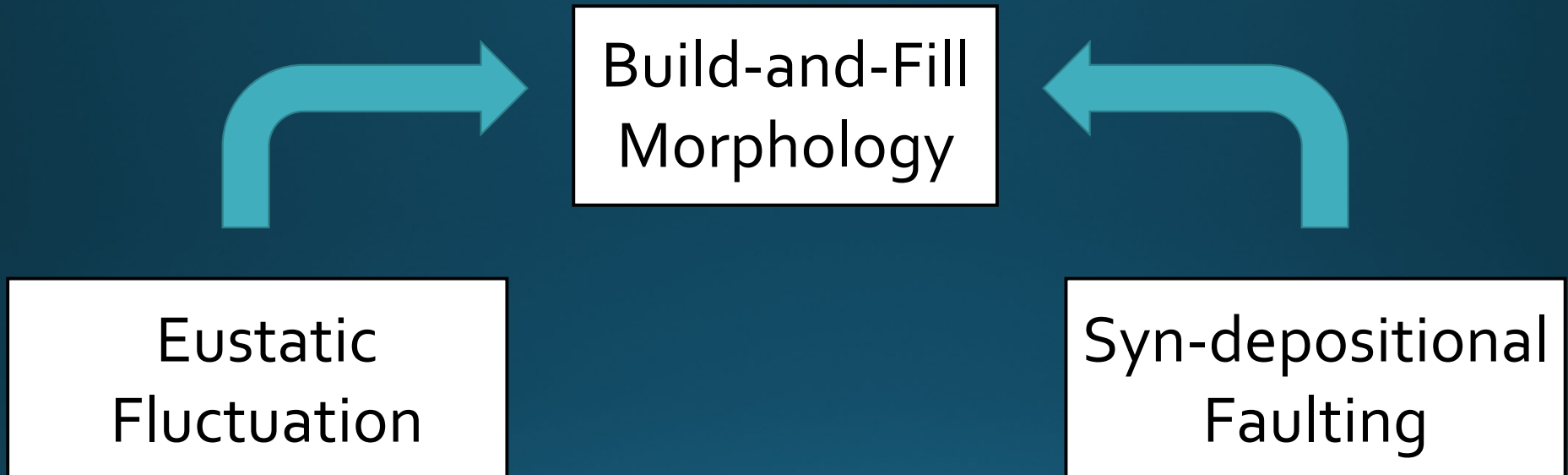


Top of Hushpuckney Shale Mbr.

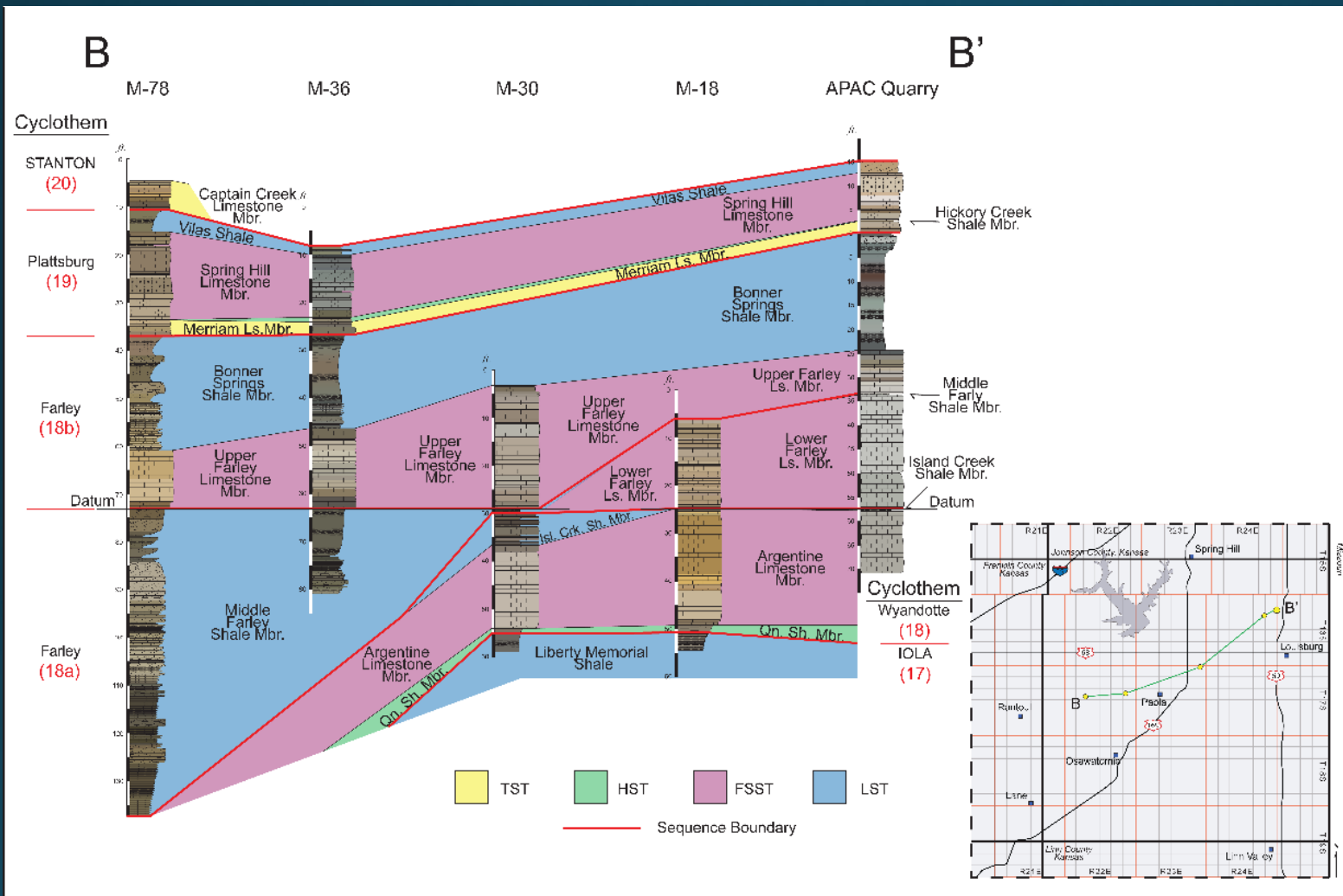
Average unit thickness variability of ~2.5 feet



What do we know so far

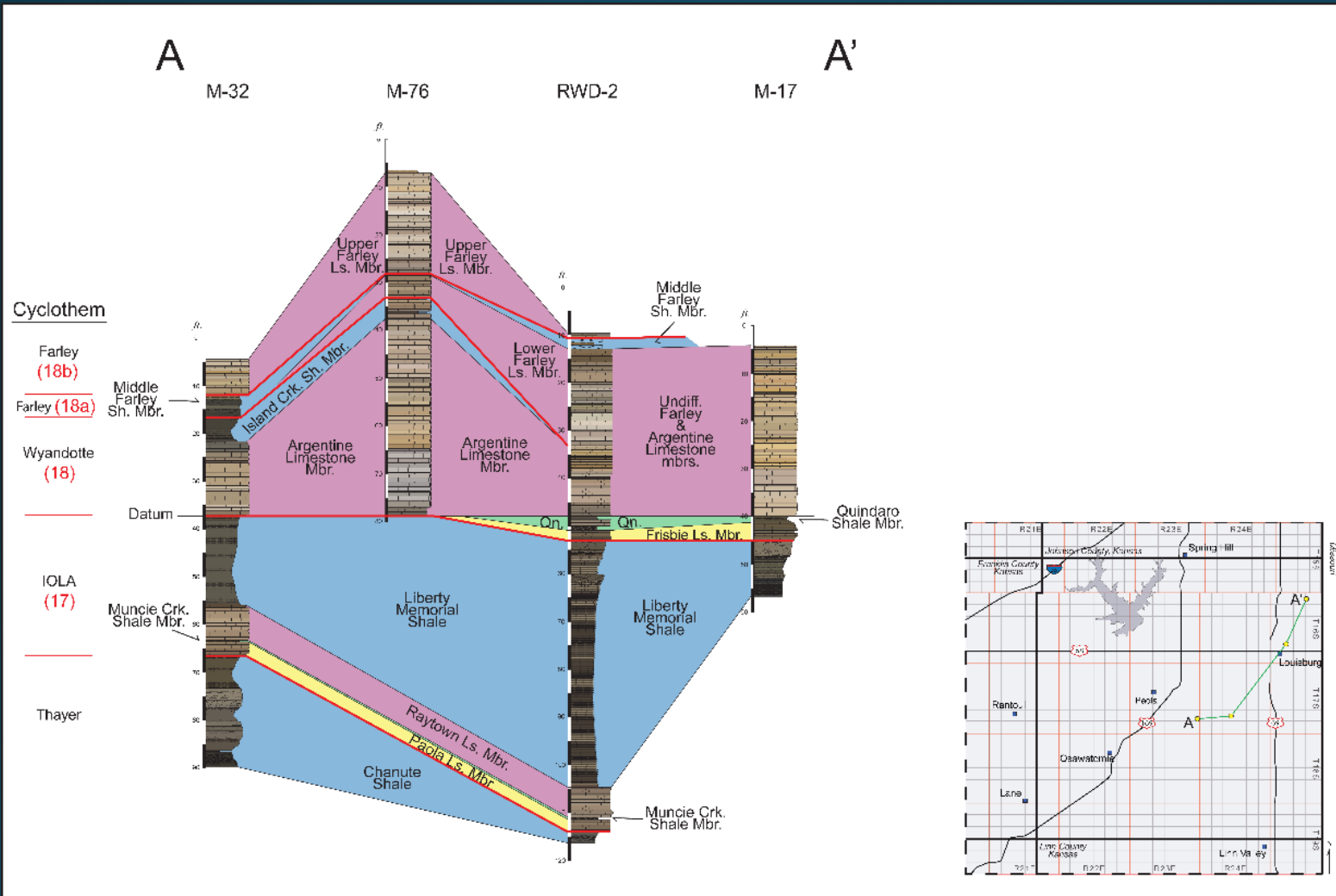


What we now need is a sequence stratigraphic framework to understand when, why, and how aggradation is occurring.



NEW CLASSIFICATION for KANSAS (Heckel and Watney, 2002)

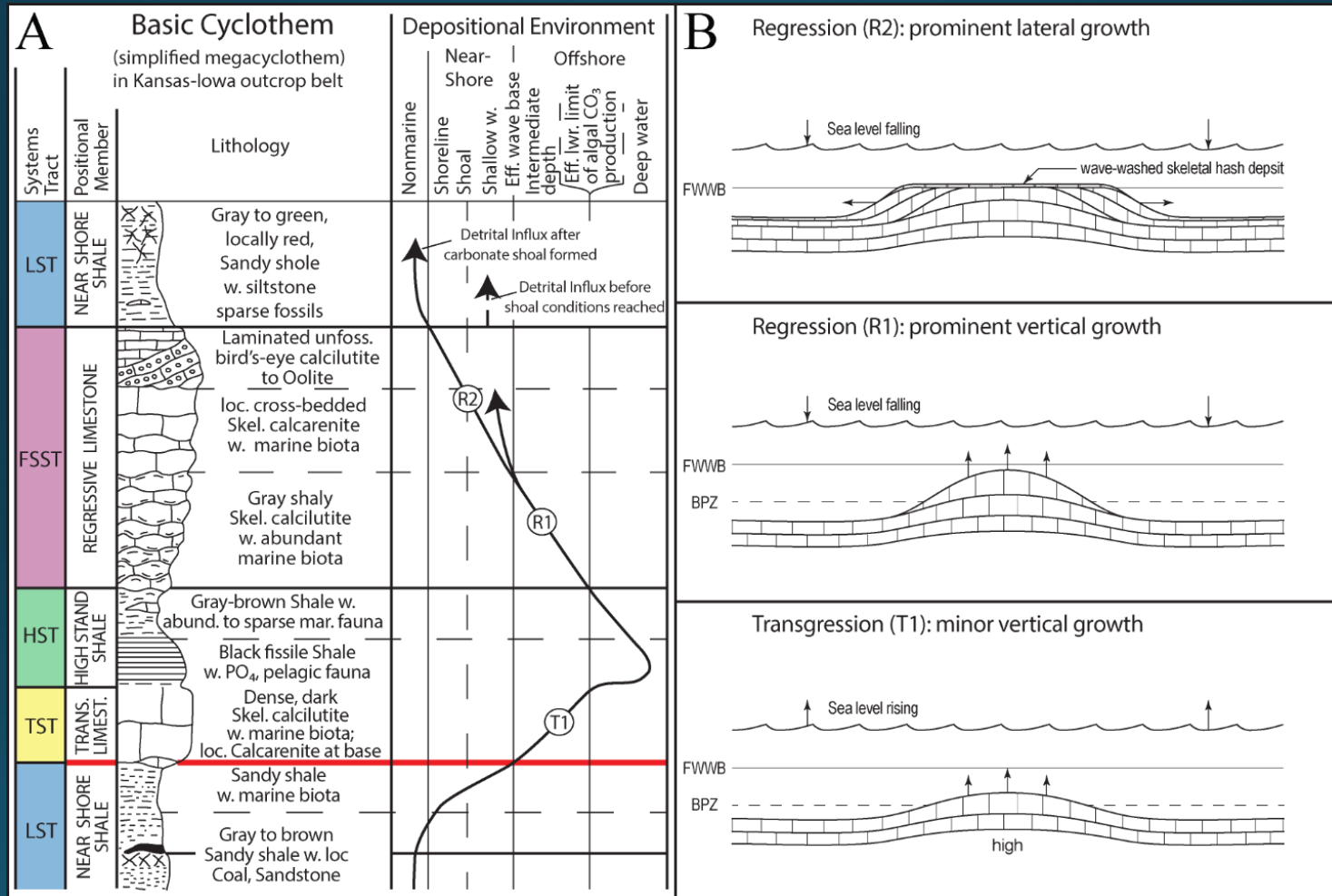
MISSOURIAN STAGE	KANSAS CITY GROUP	ZARAH SUBGROUP	LANSING GROUP	
			SOUTH BEND LS.	ROCK LAKE SHALE
MISSOURIAN STAGE	KANSAS CITY GROUP	ZARAH SUBGROUP	STANTON LS.	Little Kaw Ls. Mbr. Stoner Ls. Mbr. Eudora Sh. Mbr. Captain Creek Ls. Mbr.
			PLATTSBURG LS.	VILAS SH. Spring Hill Ls. Mbr. Hickory Creek Sh. Mbr. Merriam Ls. Mbr. Bonner Springs Sh. Mbr.
			LANE SH.	Farley Ls. Mbr. Island Creek Sh. Mbr.
			WYANDOTTE LS.	Argentine Ls. Mbr. Quindaro Sh. Mbr. Frisbie Ls. Mbr.
			LIBERTY MEMORIAL SHALE	
			IOLA LS.	Raytown Ls. Mbr. Muncie Creek Sh. Mbr. Paola Ls. Mbr.
			CHANUTE SH.	Cottage Grove Ss. Mbr. Noxie Ss. Mbr.



NEW CLASSIFICATION for KANSAS (Heckel and Watney, 2002)

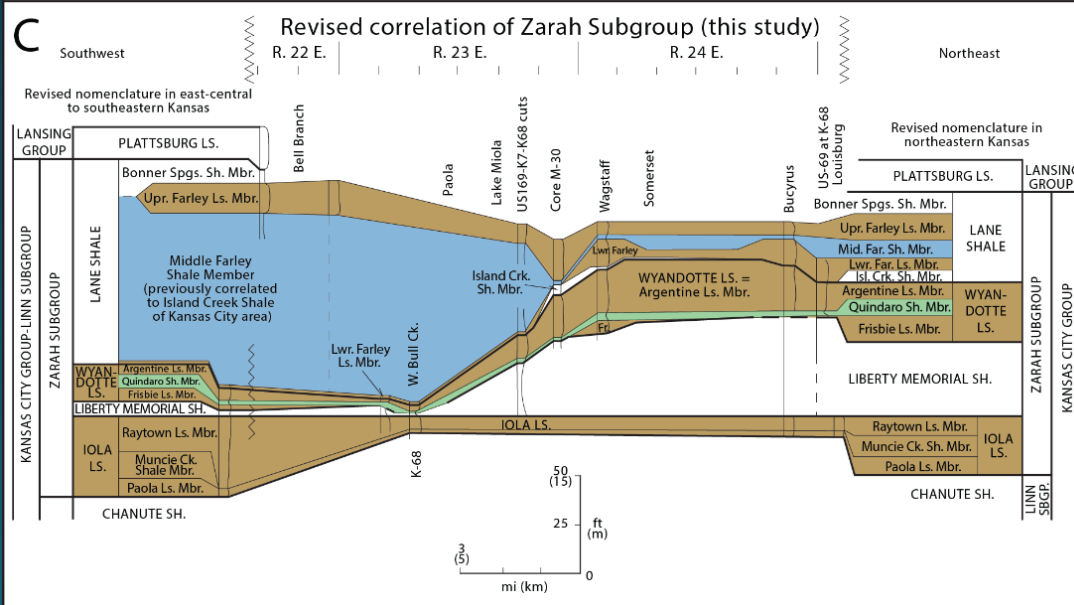
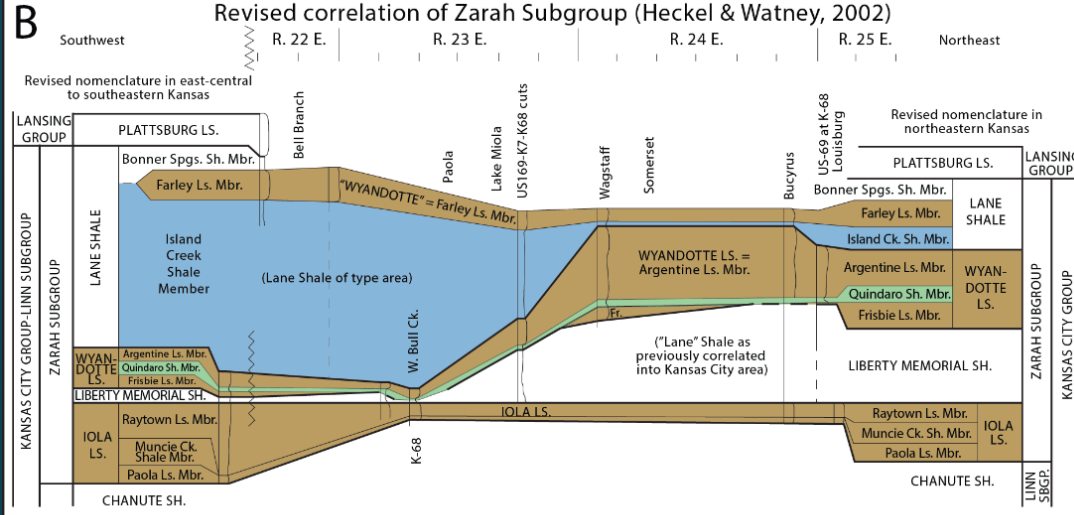
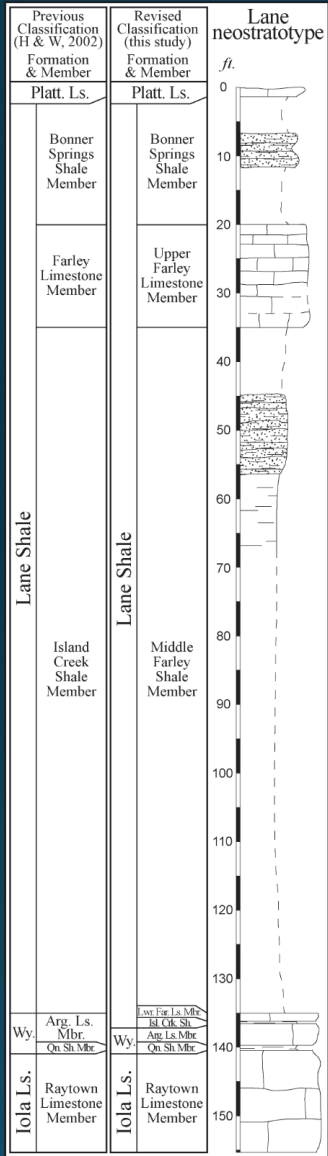
MISSOURIAN STAGE	LANSING GROUP	SOUTH BEND LS.	Little Kaw Ls. Mbr.	
		ROCK LAKE SHALE		
		STANTON LS.	Stoner Ls. Mbr.	
			Eudora Sh. Mbr.	
			Captain Creek Ls. Mbr.	
	VILAS SH.			
	PLATTSBURG LS.	Spring Hill Ls. Mbr.		
		Hickory Creek Sh. Mbr.		
	KANSAS CITY GROUP	ZARAH SUBGROUP	LANE SH.	Farley Ls. Mbr.
				Island Creek Sh. Mbr.
WYANDOTTE LS.		Argentine Ls. Mbr.		
		Quindaro Sh. Mbr.		
		Frisbie Ls. Mbr.		
LIBERTY MEMORIAL SHALE				
LISS	IOLA LS.	Raytown Ls. Mbr.		
		Muncie Creek Sh. Mbr.		
	CHANUTE SH.	Paola Ls. Mbr.		
		Cottage Grove Ss. Mbr.		
		Noxie Ss. Mbr.		

Let's now incorporate facies



Outline

- 1) Paleogeography; Present Nomenclature; Previous Interpretation as of 1990 and the stratigraphic questions that arose with that research
- 2) New depositional interpretation and new unit identification
- 3) Implications of this research and recommendations for the future.



Implications to the nomenclature

NEW CLASSIFICATION for KANSAS (Heckel and Watney, 2002)

MISSOURIAN STAGE	LANSING GROUP	SOUTH BEND LS.	Little Kaw Ls. Mbr.					
		ROCK LAKE SHALE	Stoner Ls. Mbr.	Eudora Sh. Mbr.	Captain Creek Ls. Mbr.			
KANSAS CITY GROUP	ZARAH SUBGROUP	VILAS SH.	Spring Hill Ls. Mbr.	Hickory Creek Sh. Mbr.	Merriam Ls. Mbr.	Bonner Springs Sh. Mbr.		
		PLATTSBURG LS.	LANE SH.	Farley Ls. Mbr.	Island Creek Sh. Mbr.	ARGENTINE Ls. Mbr.	QUINDARO Sh. Mbr.	FRISBIE Ls. Mbr.
		LIBERTY MEMORIAL SHALE	RAYTOWN Ls. Mbr.	MUNCIE CREEK Sh. Mbr.	PAOLA Ls. Mbr.			
		IOLA Ls.	CHANNUTE SH.	COTTAGE GROVE Ss. Mbr.	NOXIE Ss. Mbr.			

Nomenclature

Formations Studied



Limestone Dominated



Shale Dominated

- Bonner Springs Shale
- Iola Limestone

MISSOURIAN STAGE	LANSIN	VILAS SH.		VILAS SH.		LANSIN	
		PLATTSBURG LS.	Spring Hill Ls. Mbr.	Spring Hill Ls. Mbr.	PLATTSBURG LS.		
			Hickory Creek Sh. Mbr.	Hickory Creek Sh. Mbr.			
	Merriam Ls. Mbr.		Merriam Ls. Mbr.				
	ZARAH SUBGROUP	BONNER SPRINGS SH.				LANE SH.	
		WYANDOTTE LS.	Farley Ls. Mbr.				Island Creek Sh. Mbr.
			Island Creek Sh. Mbr.				Island Creek Sh. Mbr.
			Argentine Ls. Mbr.	Argentine Limestone Mbr.			
			Quindaro Sh. Mbr.	Quindaro Shale Mbr.			
			Frisbie Ls. Mbr.	Frisbie Limestone Mbr.			
		LANE SH.		LIBERTY MEMORIAL SH.		ZARAH SUBGROUP	
		IOLA LS.	Raytown Ls. Mbr.	Raytown Limestone Mbr.	IOLA LS.		
			Muncie Creek Sh. Mbr.	Muncie Creek Shale Mbr.			
			Paola Ls. Mbr.	Paola Limestone Mbr.			
CHANUTE SH.	Cottage Grove Ss. Mbr.	Cottage Grove Ss. bed	CHANUTE SH.				
	Noxie Ss. Mbr.	Thayer coal bed Noxie Ss. bed					
	Corbin City Ls. Mbr.	Cement City Ls. Mbr.					
	Dewey Ls. Mbr.	Quivira Sh. Mbr.					
DRUM LS.			DEWEY LS.				
	NELLIE BLY FORMATION						
CITY GROUP			CITY GROUP				
				MISSOURIAN STAGE			
				PENNSYLVANIAN SERIES			

Recommendations for the Future

- 1) update all quarry nomenclature
- 2) add to known geodatabases
- 3) incorporate pXRF
- 4) more work
 - throughout the region
 - throughout the underlying and overlying strata
- 5) more funding

In Summary

- 1) resolved the need for a southerly sediment source
- 2) eliminated Lane-Island Creek within the literature
- 3) revised the Lane Neostatotype
- 4) formalize the Farley submembers
- 5) build-and-fill modulated by eustatic sea-level fluctuation and syn-depositional faulting.
- 6) carbonate accumulation primarily during FSST
- 7) carbonate mounds aggrade and prograde
- 8) Zeller (1968), Heckel and Watney (2002), this study

Acknowledgments

- Funding provided through the State Map Program at the Kansas Geological Survey (KGS) and the University of Iowa Department of Earth and Environmental Sciences
- Core provided by the Kansas Department of Transportation (KDOT)
- Brad Cramer at the University of Iowa; Greg Ludvigson, Robert Sawin, Jeff Ross, Lynn Watney, David Newell, and David Laflen at the KGS; Bob Henthorne at KDOT; Dan Jones at the APAC Quarry
- Field assistant (i.e., my beautiful wife)
- University of Iowa Paleontology Repository



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Some data presented in this talk was later published in Oborny et al. (2017)

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