Regional Aspects of Stratal Architecture of the Subsurface Mississippian in Kansas Based on Wireline Log Cross-Sections and Seismic*

Brian Wilhite[1] and Sal Mazzullo[1]

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Abstract

The lithostratigraphic architecture of the Mississippian in subsurface Kansas is inherently complex, and to complicate it further, it was then overprinted by syndepositional as well as pre-Cherokee tectonics. Yet, the component lithostratigraphic units within the section, and most importantly the petroleum reservoirs therein, can in fact be identified on log cross-sections and resolved seismically, with detailed subsurface mapping and core-well cuttings sample analyses. Because different Mississippian lithologic units behave differently in terms of their reservoir production and completion attributes, it is critical to identify the specific exploration objective in an area. The Kinderhookian to basal Osagean part of the section is readily identified based on its generally non-cherty character, local presence of reefs, and mostly aggradational ramp-like, 3-D depositional geometry. These rocks are present throughout Kansas, except for where they have been eroded from positive areas. Overlying Osagean strata dramatically contrast the older rocks, and they are recognized by their siliceous character (spiculite, tripolite, and chert) and dominant progradational geometry, with some internal erosional truncations, that are identifiable seismically. These rocks are present only in southern Kansas, and extend into Oklahoma. Major transgression ensued early in Meramecian time, and the resulting geometries of these units include initially onlapping wedges replaced by later aggradational to progradational, carbonate-dominated systems, both of which locally are truncated by major unconformities.

REGIONAL ASPECTS OF STRATAL ARCHITECTURE OF THE SUBSURFACE MISSISSIPPIAN IN KANSAS BASED ON WIRELINE LOG CROSS-SECTIONS AND SEISMIC

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ACKNOWLEDGEMENTS:

Wilhite would like to acknowledge his co-author and fellow colleagues over the course of the past 8 years of outcrop to subsurface research. Wayne Woolsey is recognized for support and latitude in the efforts of applying science to the drillbit to establish hydrocarbon production.

Mazzullo concurs; he also specifically acknowledges the Nero D' Avola Wineries.

IN THIS TALK...

*** Revisit the outcrop, and subsurface, based depositional systems models and component lithostratigraphic units with special focus on the Osage and lower Meramec**

*** Illustrate some of the lithostratigraphic complexities particularly along the 'main-shelf' / 'shelf-break' transition in southern Kansas and northern Oklahoma**

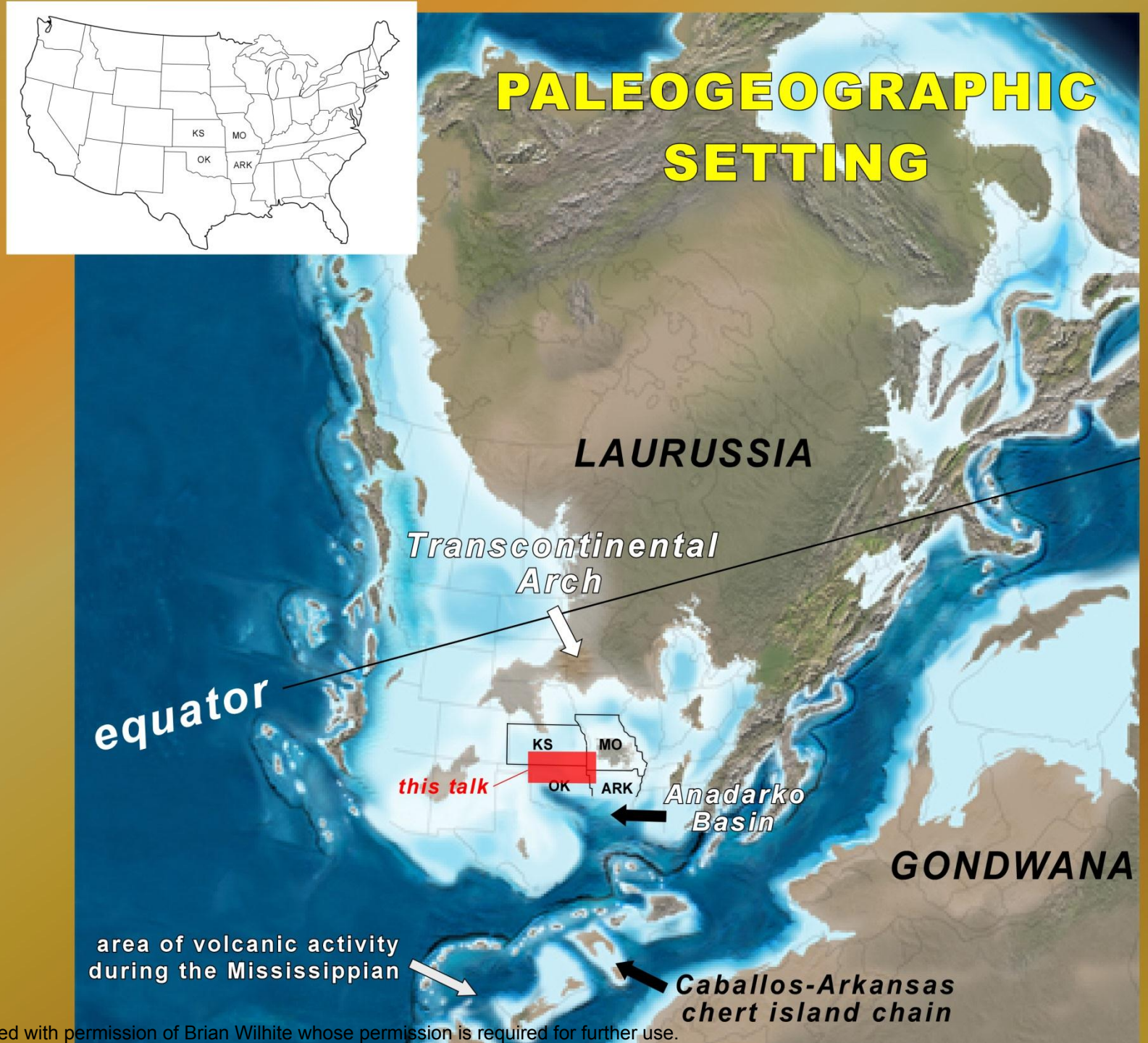
*** Although seemingly various and complex, these stratal relations form predictable stacking patterns that represent reality and can be recognized:**

1.) on log cross-section, through core/cuttings analysis

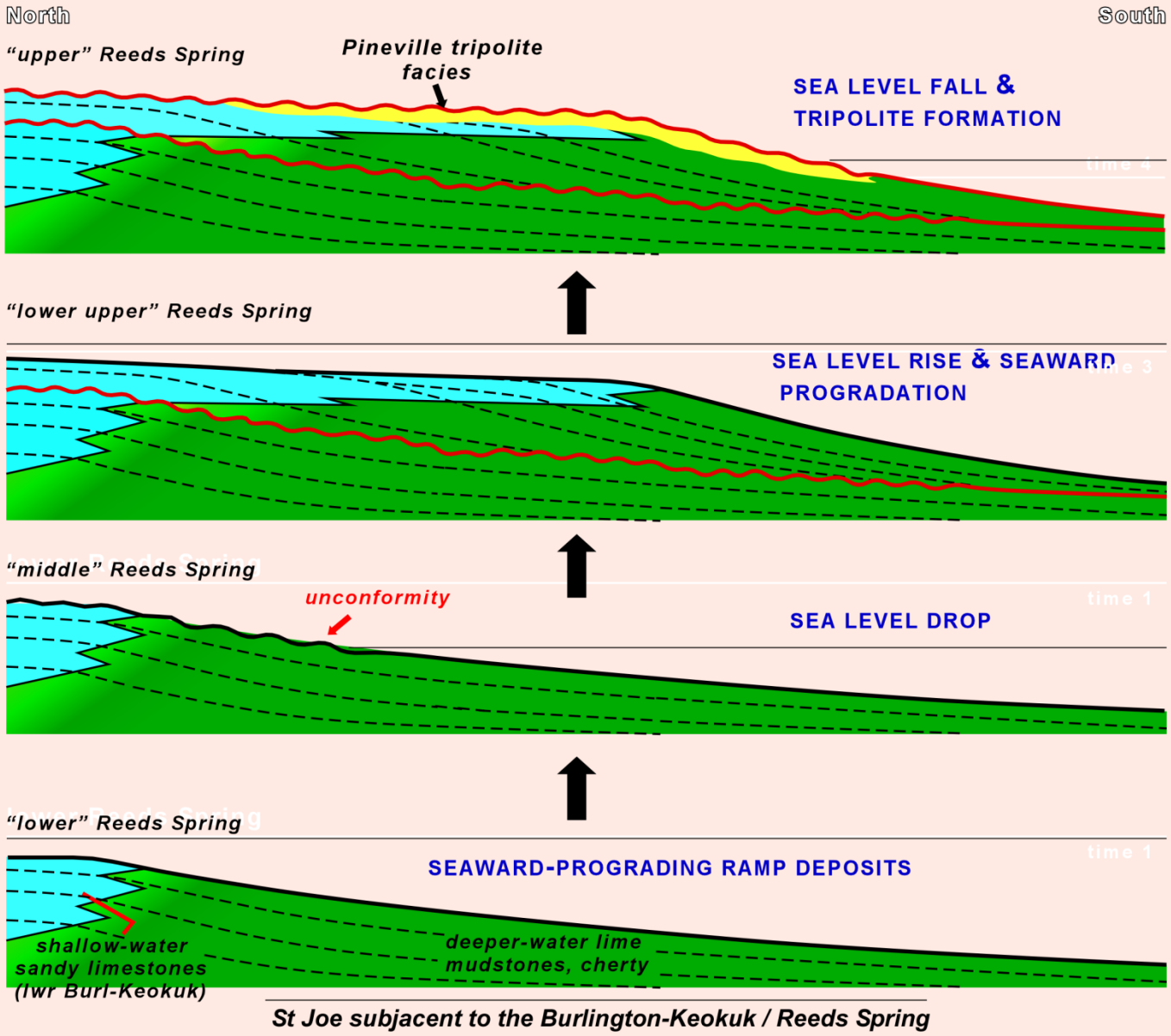
&

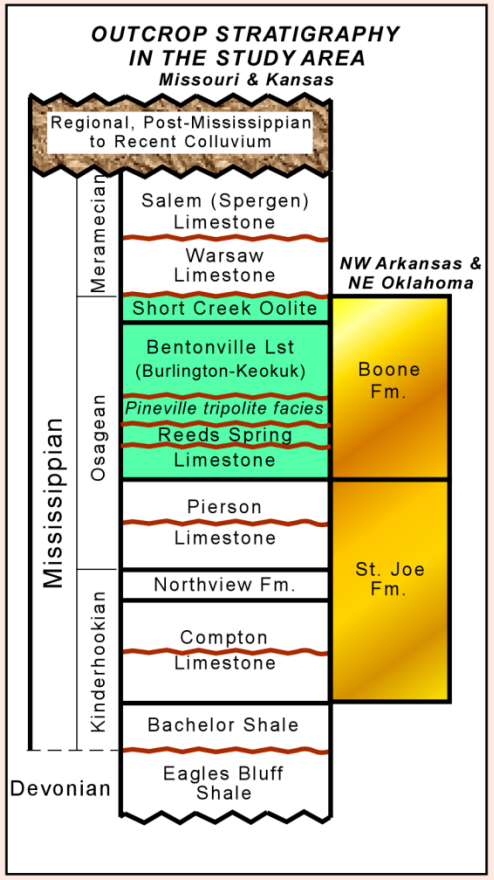
2.) in seismic, and specifically on seismic impedance models, complete with onlapping, downlapping and progradational geometries

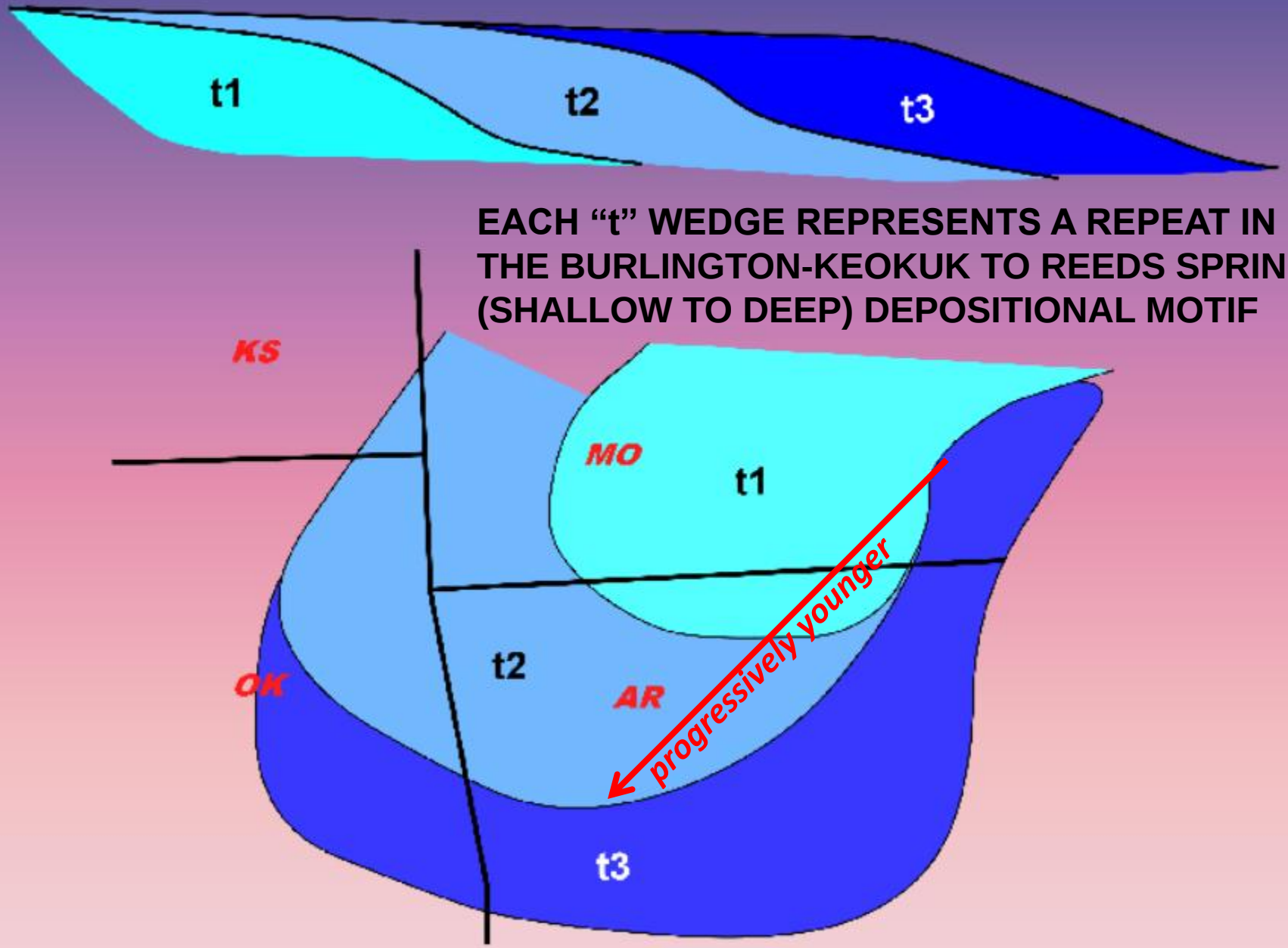
*** Being able to delineate different depositional systems on and along the 'shelf-break', component petroleum systems and objectives, addressed in the previous talk, can be recognized and sought out.**



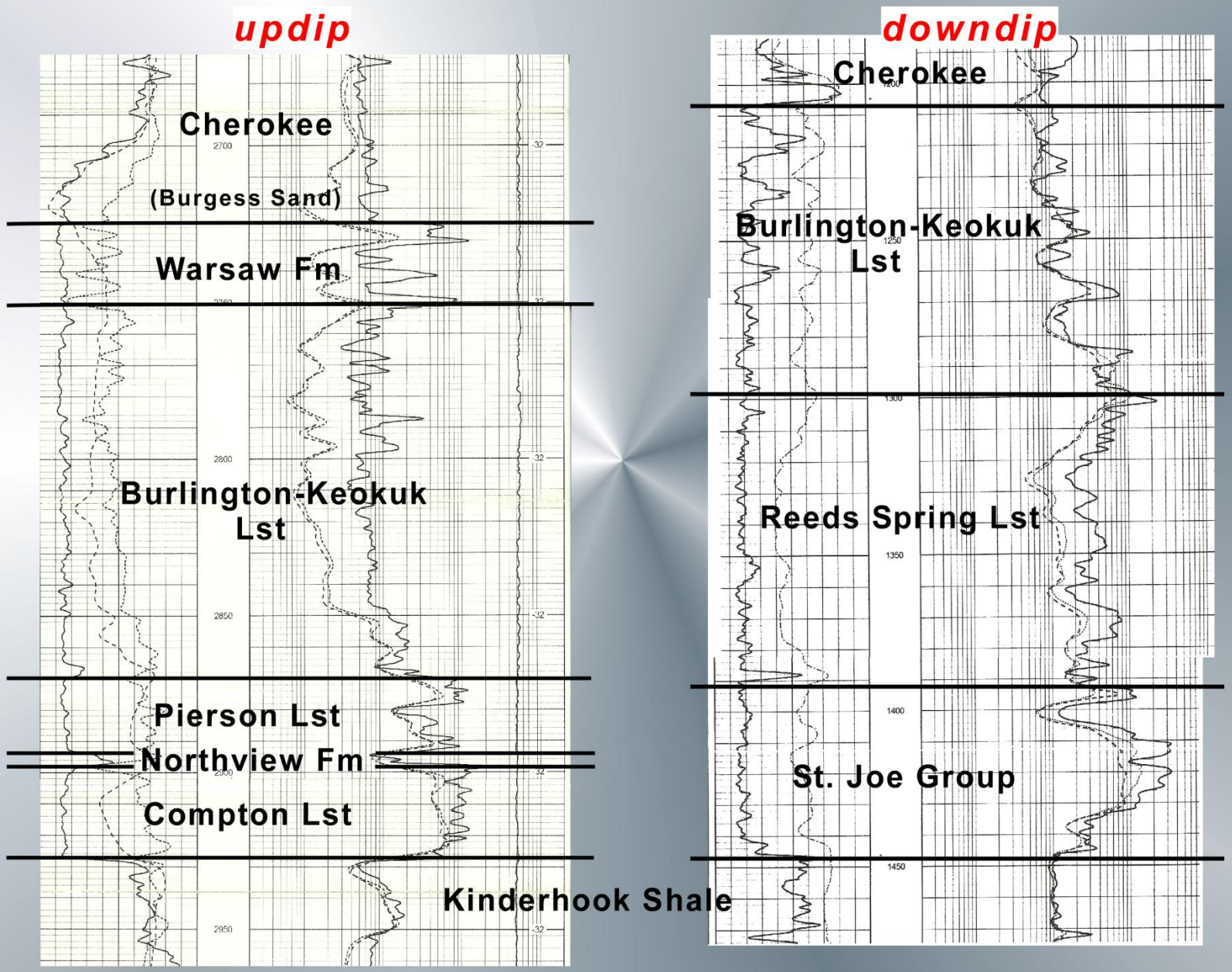
OUTCROP DEPOSITIONAL SYSTEMS MODEL



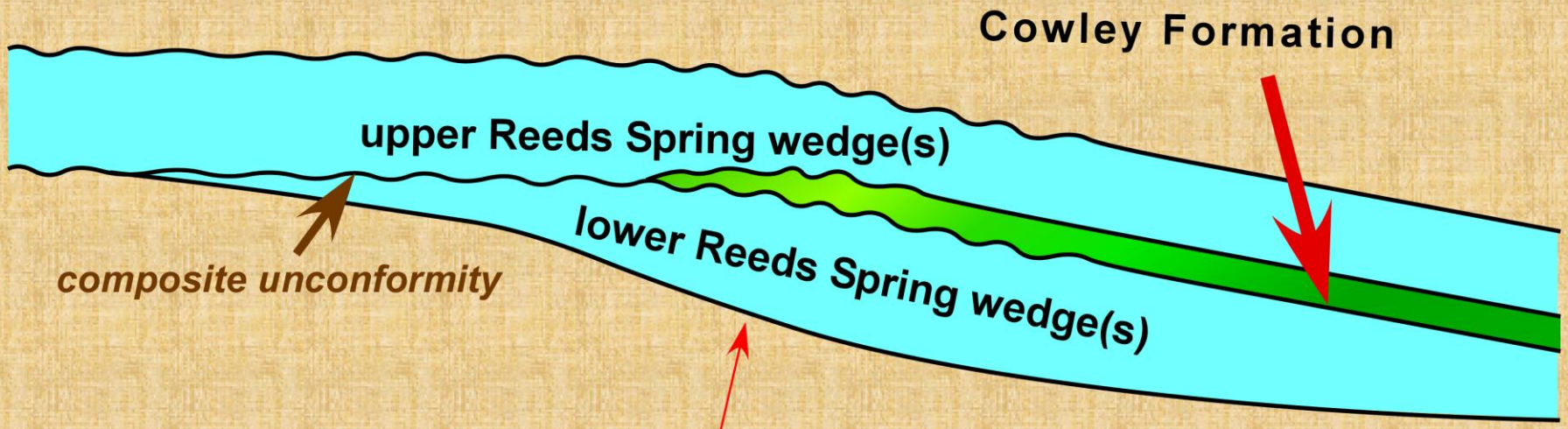


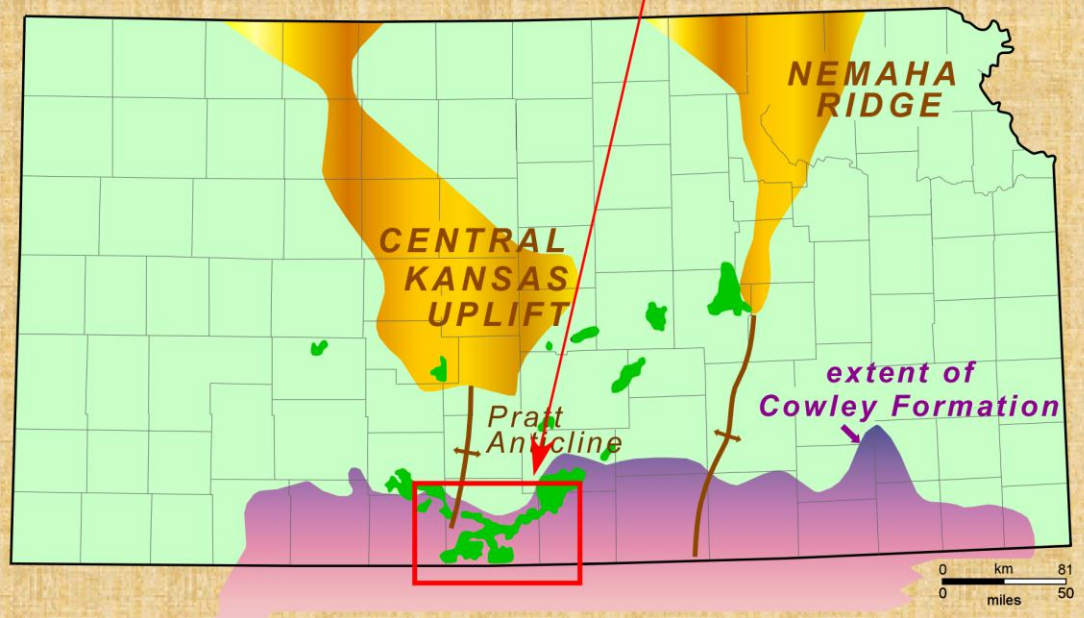


LOG SIGNATURES OF OUTCROP STRATIGRAPHY

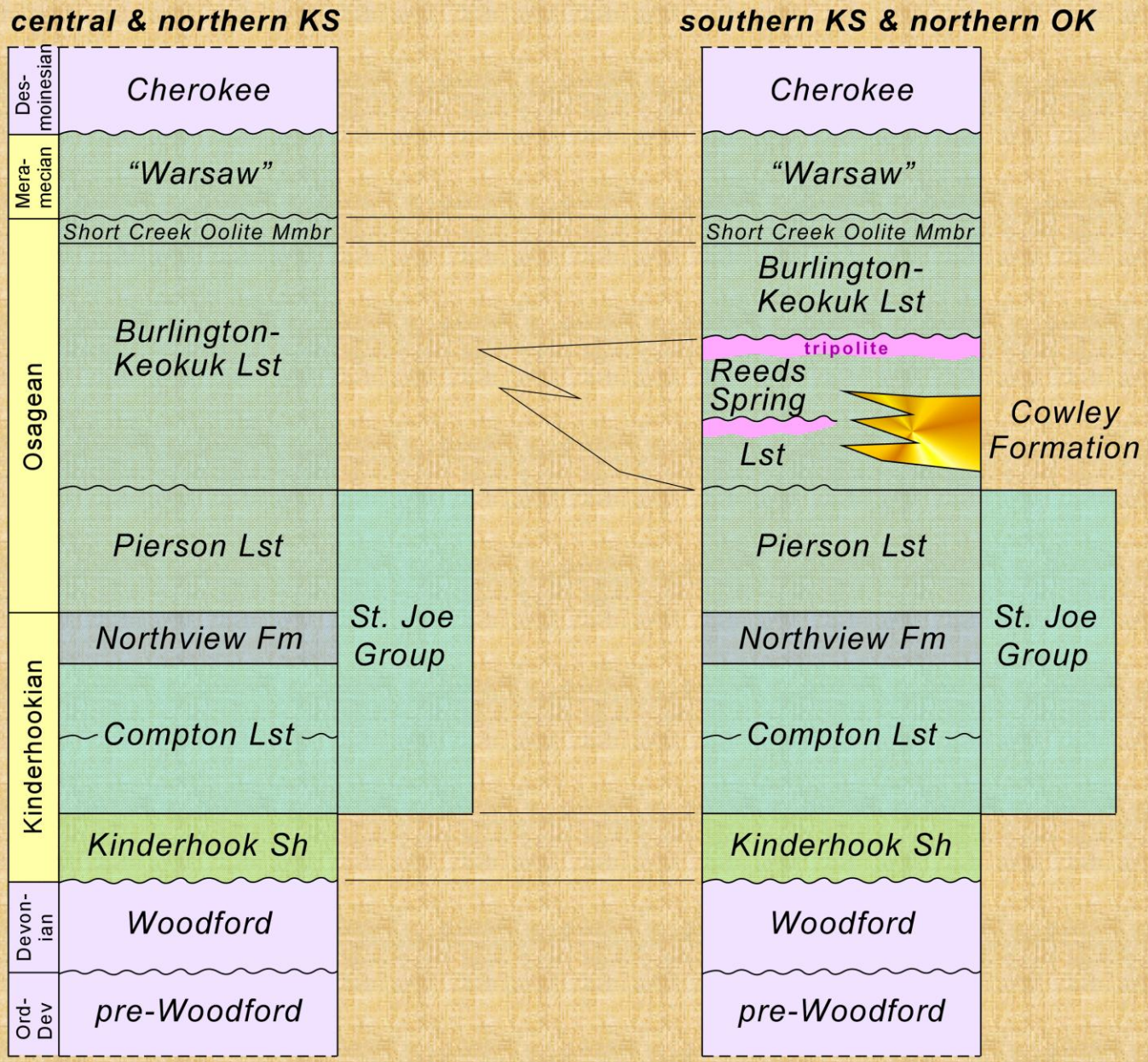


SUBSURFACE DEPOSITIONAL SYSTEMS MODEL

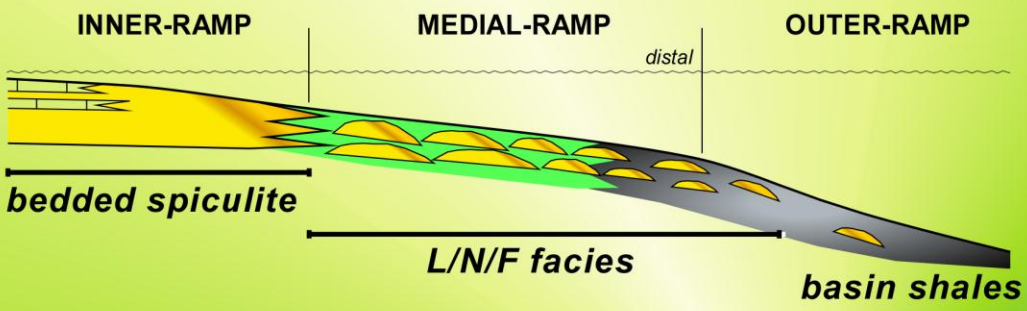




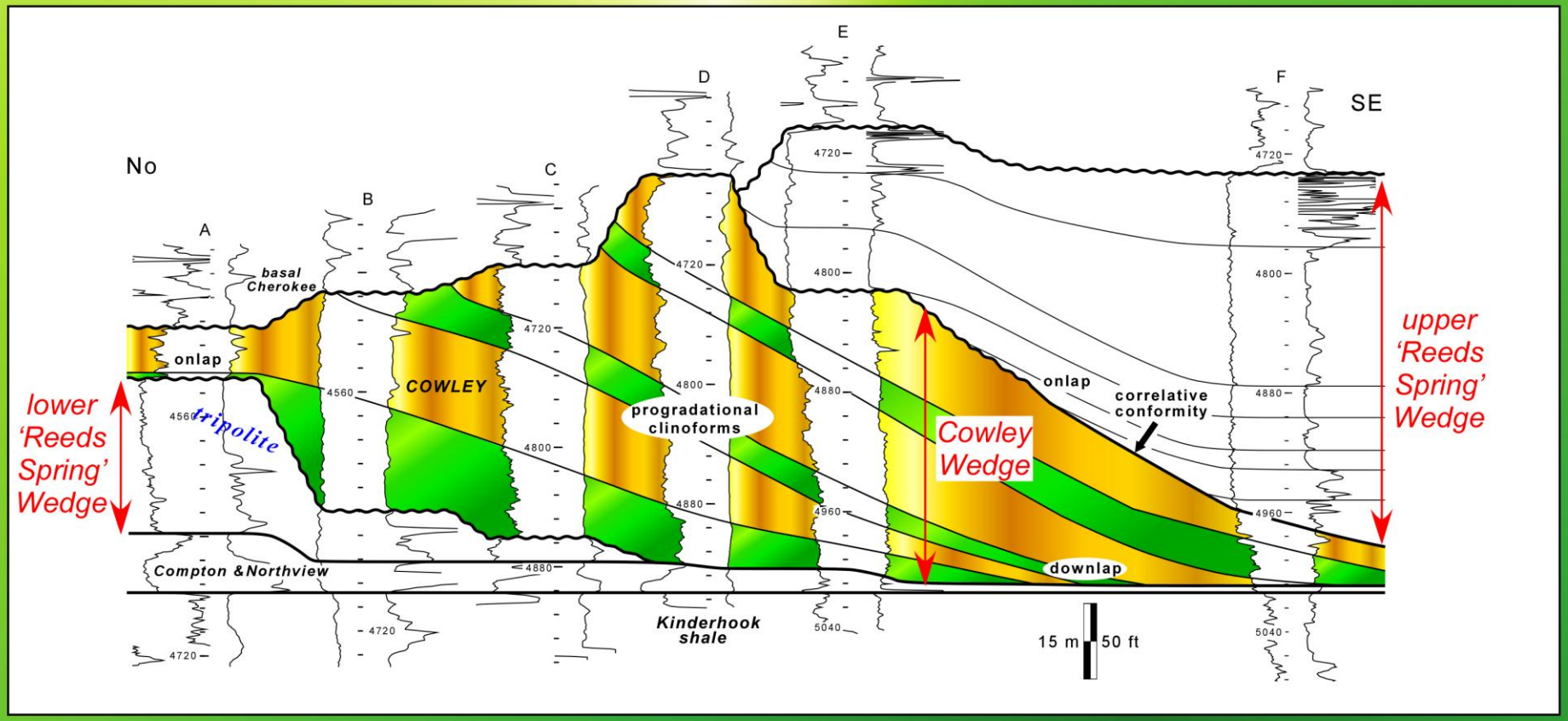
SUBSURFACE STRATIGRAPHY



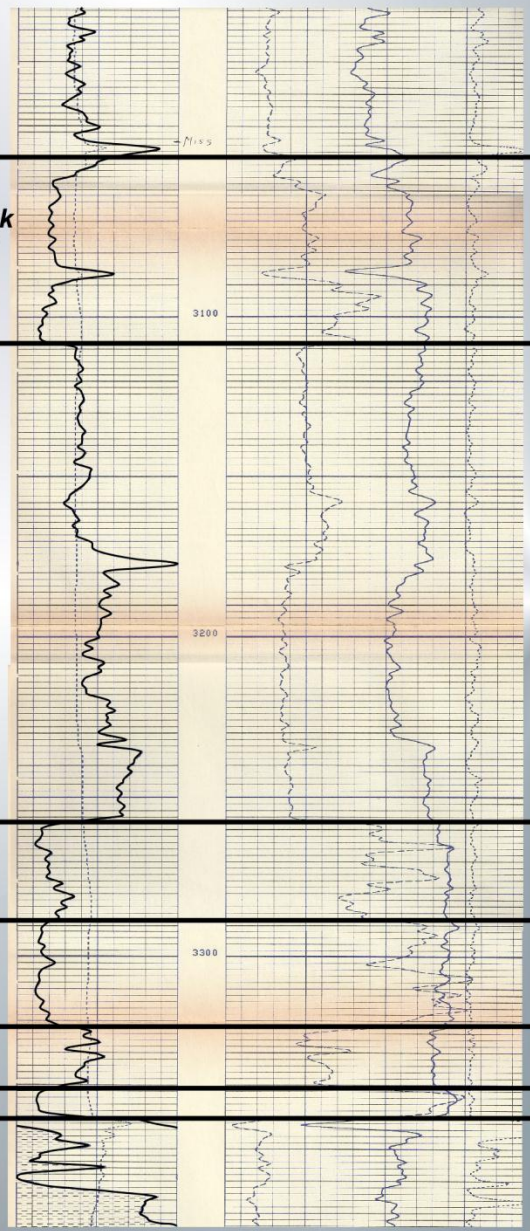
SUBSURFACE DEPOSITIONAL ARCHITECTURE & FACIES OF THE COWLEY



The Cowley was deposited on a low-angle ramp that graded seaward from relatively shallow to deeper-water environments. These facies prograded seaward as a series of separate, time-transgressive wedges



LOG SIGNATURES OF SUBSURFACE STRATIGRAPHY



Burlington-Keokuk (updip equiv. of Reeds Spring)

Cowley Fm

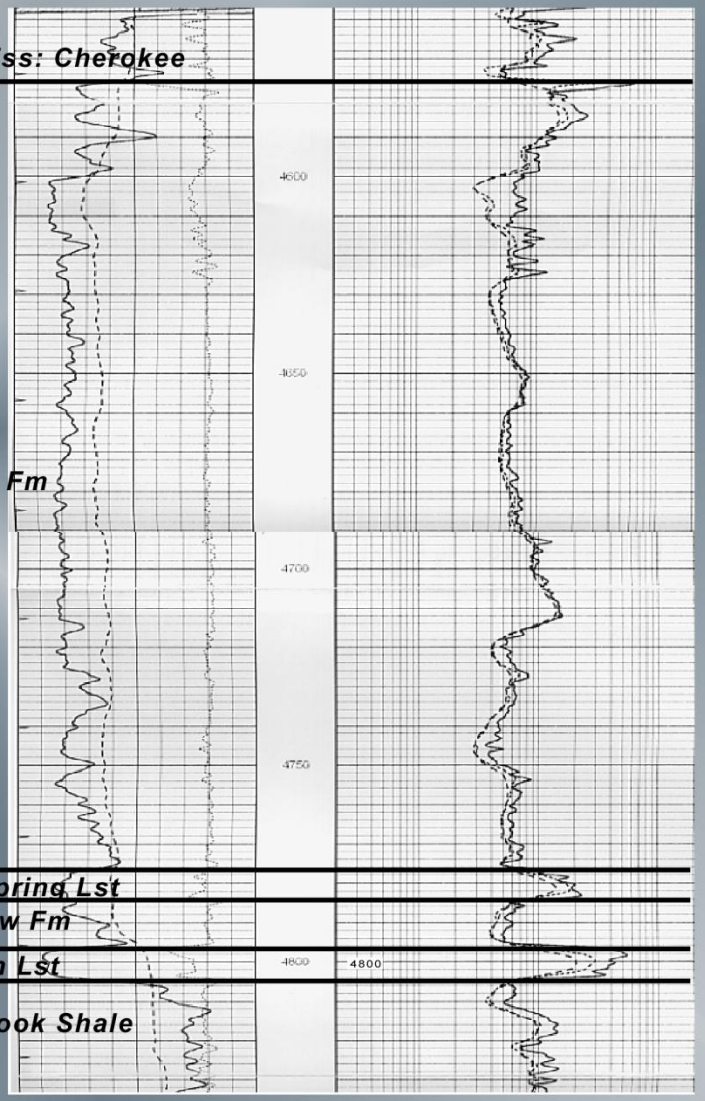
Reeds Spring Lst

Pierson Lst

Northview Fm

Compton Lst

Kinderhook Shale



Post-Miss: Cherokee

Cowley Fm

Reeds Spring Lst

Northview Fm

Compton Lst

Kinderhook Shale

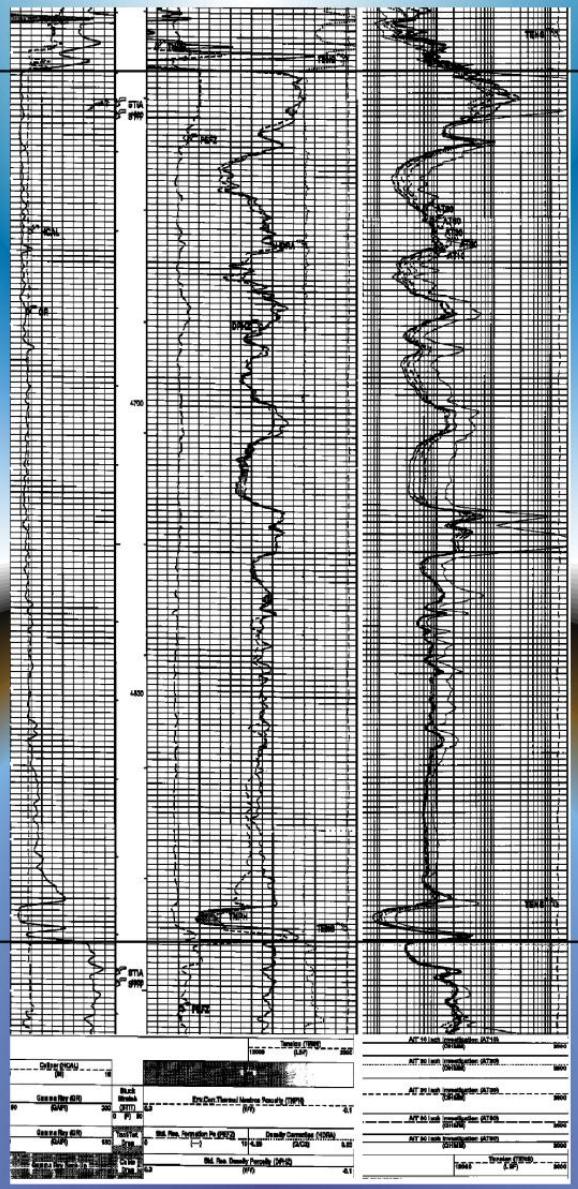
Now that you know the players....

Reeds Spring
Burlington-Keokuk
Cowley

...including their stratigraphic order
and the
facies therein, it is now time for a

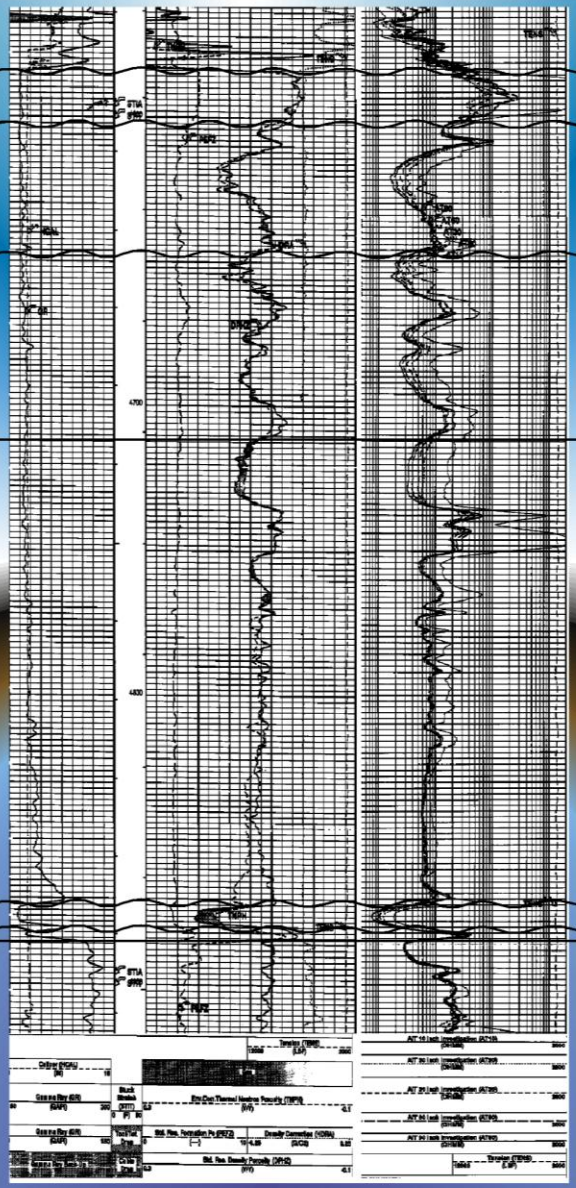
POP QUIZ!

NAME THE FORMATIONS



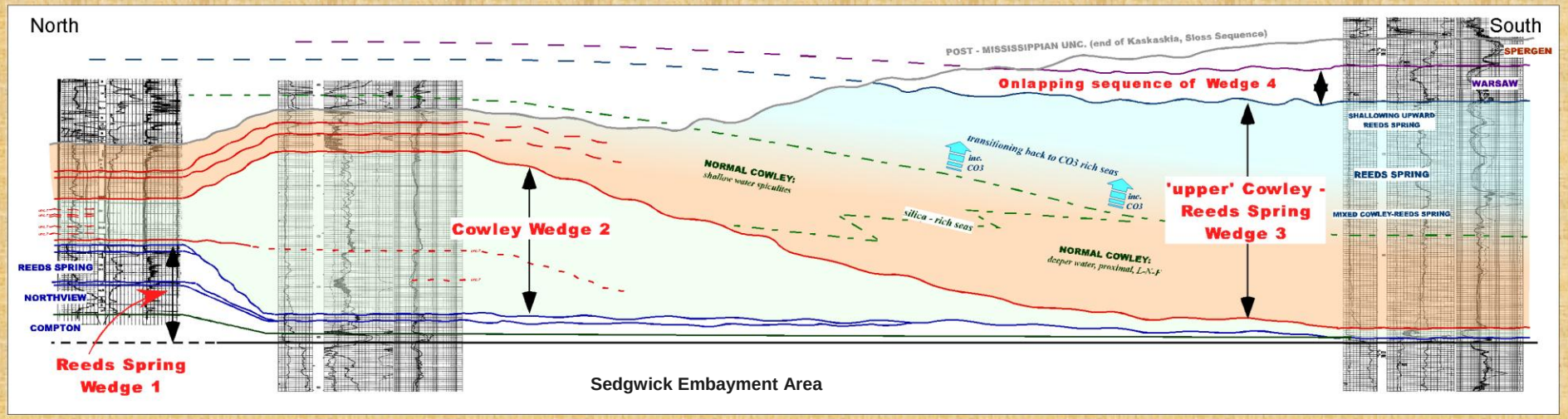
NAME THE FORMATIONS

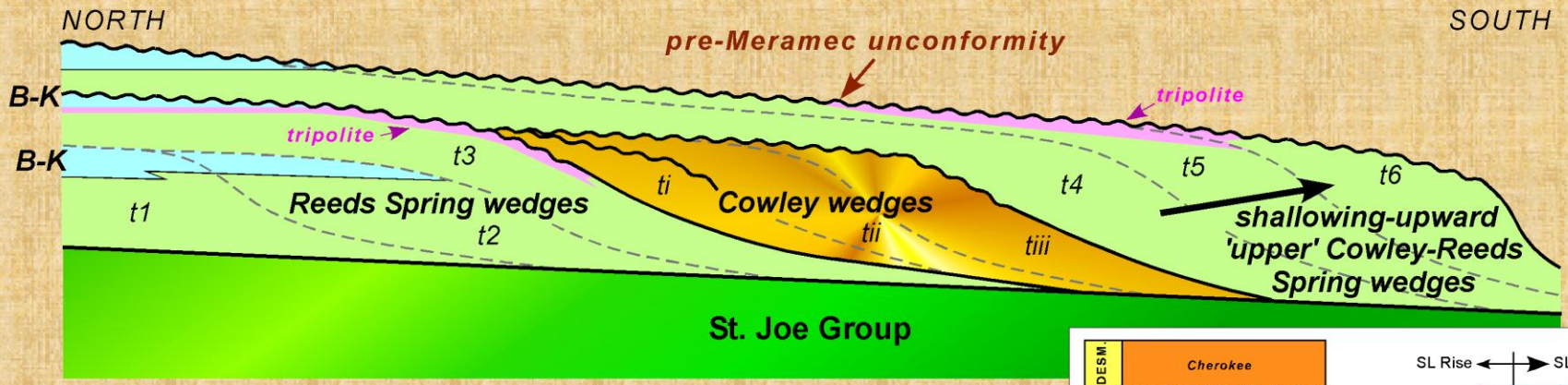
LITHOLOGICALLY COMPLEX!!



***Sample cuttings and/or core are ESSENTIAL in establishing the stratigraphy!!**

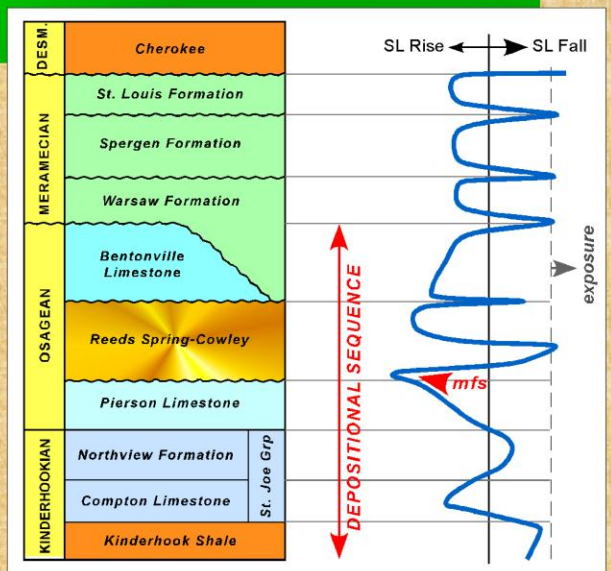
The reality is, you must know what unit you are in because reservoir objectives are specific to these intervals; nomenclature thus, is integral.



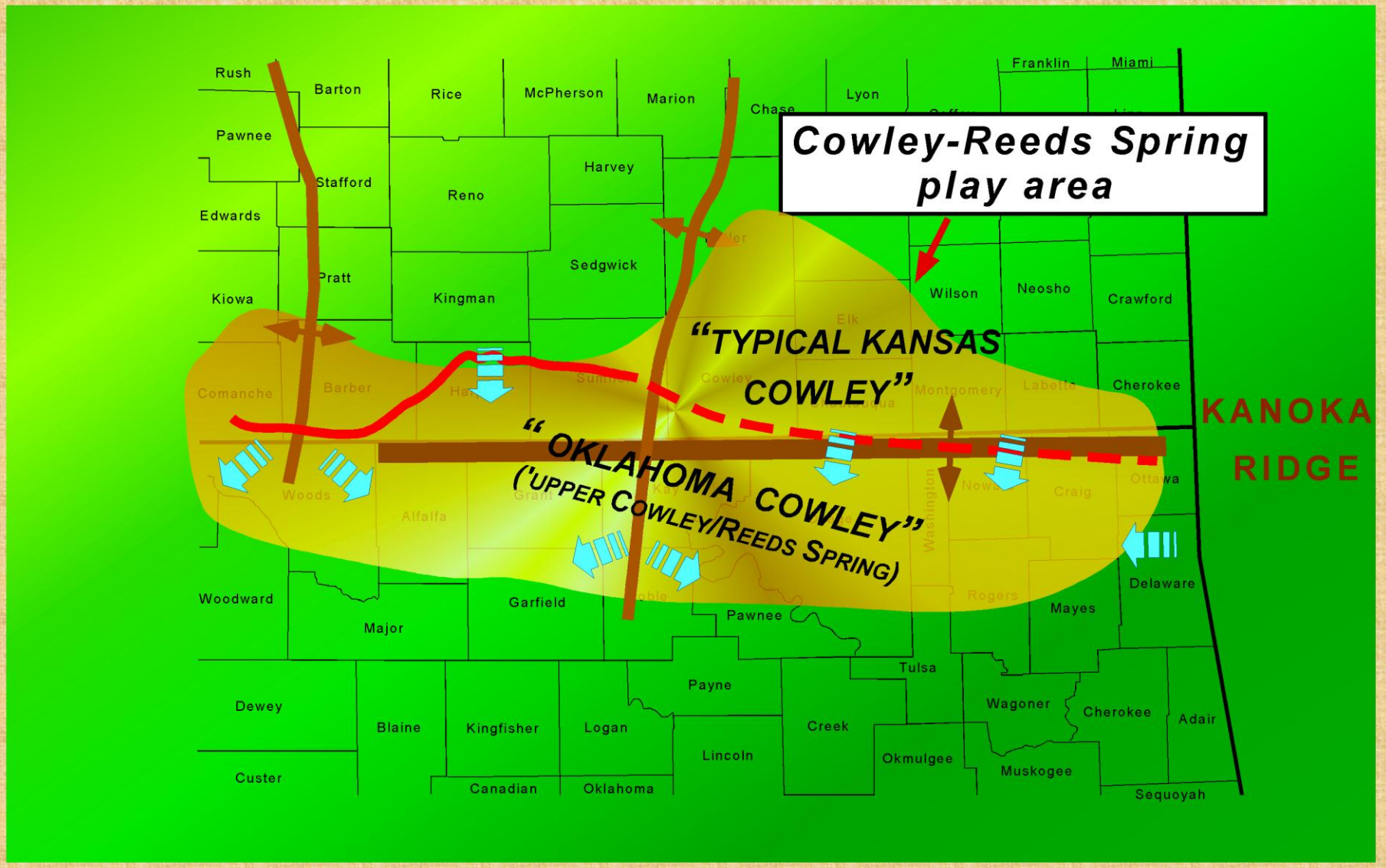


CORE CROSS-SECTION & SUB-SURFACE REEDS SPRING-COWLEY STRATIGRAPHIC ARCHITECTURE

(Relative/Eustatic Curve Based on Sedimentology & Conodont Biostratigraphy)



DIRECTIONS OF REEDS SPRING & COWLEY PROGRADATIONAL WEDGES - THAT DEFINE "BASIN COMPARTMENTS"



RECOGNIZING COMPONENT LITHOSTRATIGRAPHIC UNITS,

Reeds Spring

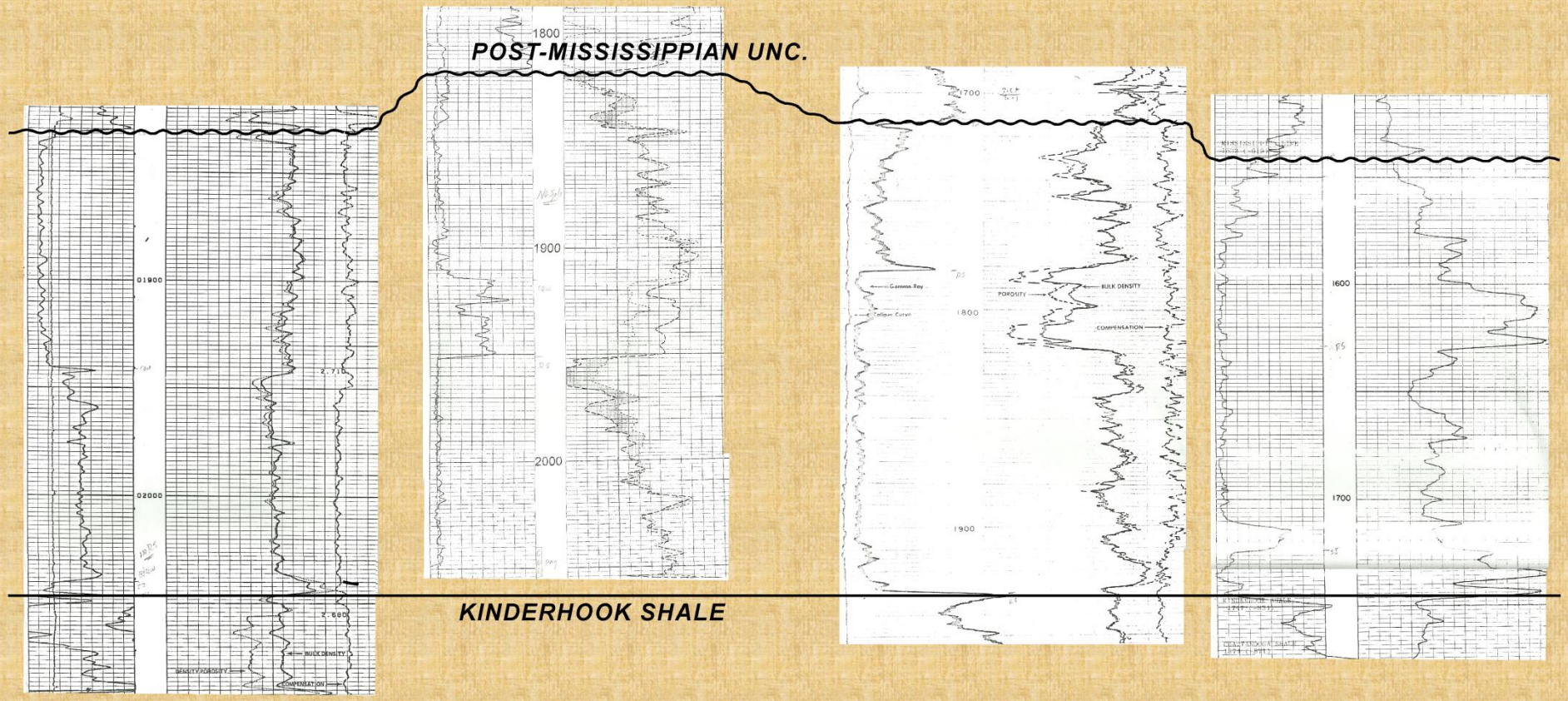
Burlington-Keokuk

Cowley Fm.

'upper' Cowley - Reeds Spring

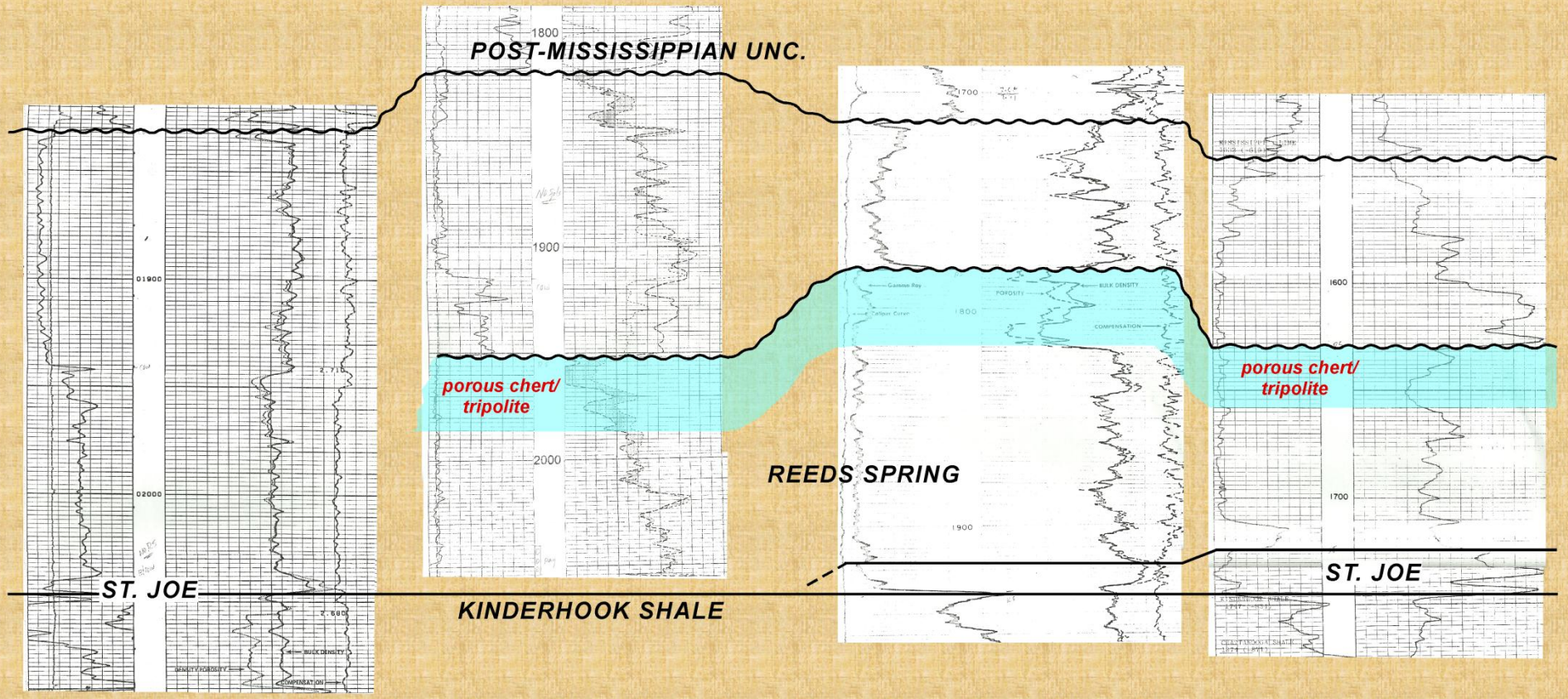
AND THEIR CORRELATIONS, ON LOG CROSS-SECTIONS

POP QUIZ #2 - WHAT ARE THE COMPONENT LITHOSTRATIGRAPHIC UNITS, AND HOW DO THEY CORRELATE?



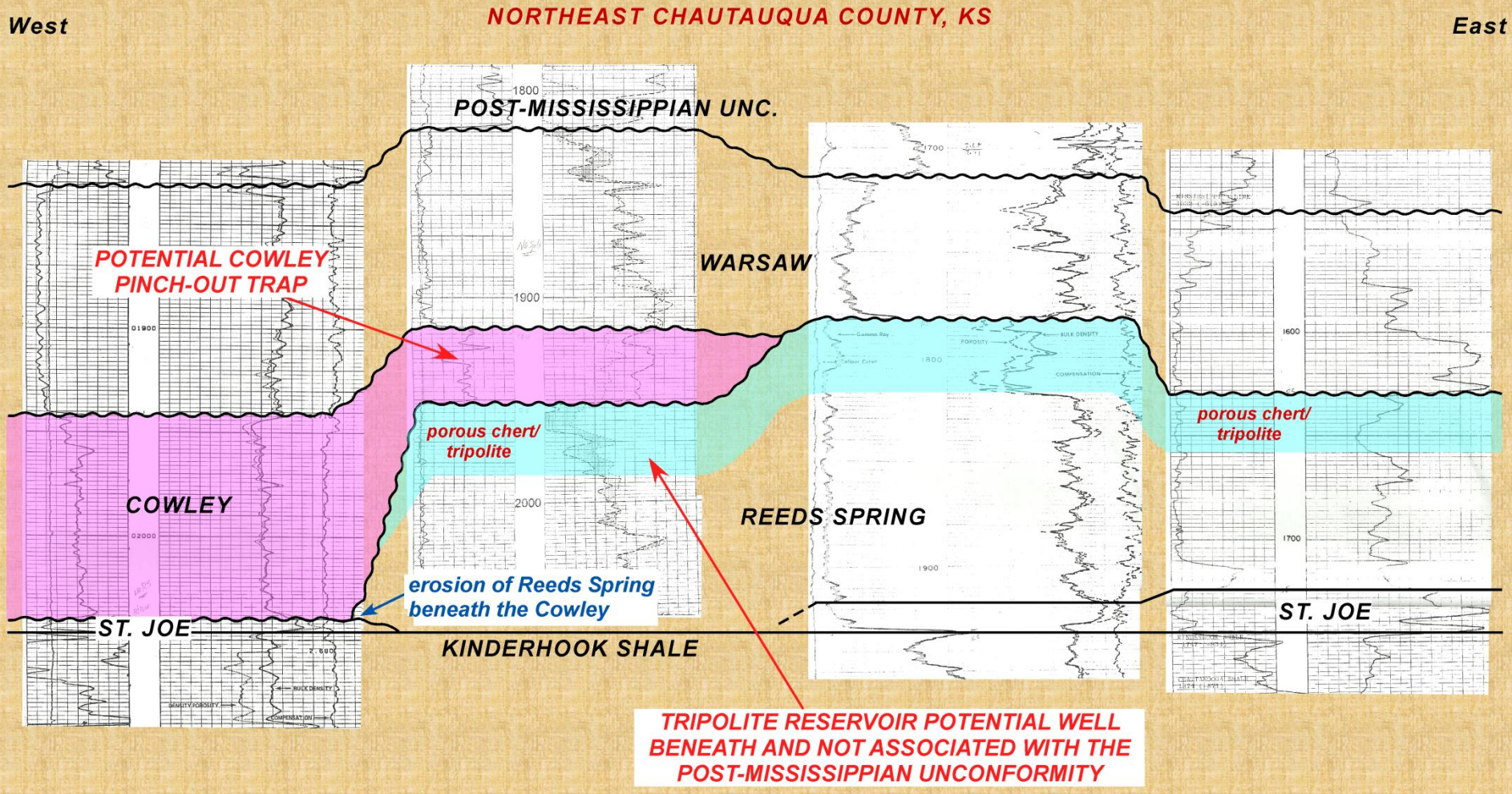
ST. JOE & 'LOWER' REEDS SPRING CORRELATIONS

HOW DOES THE POST-REEDS SPRING CORRELATE?

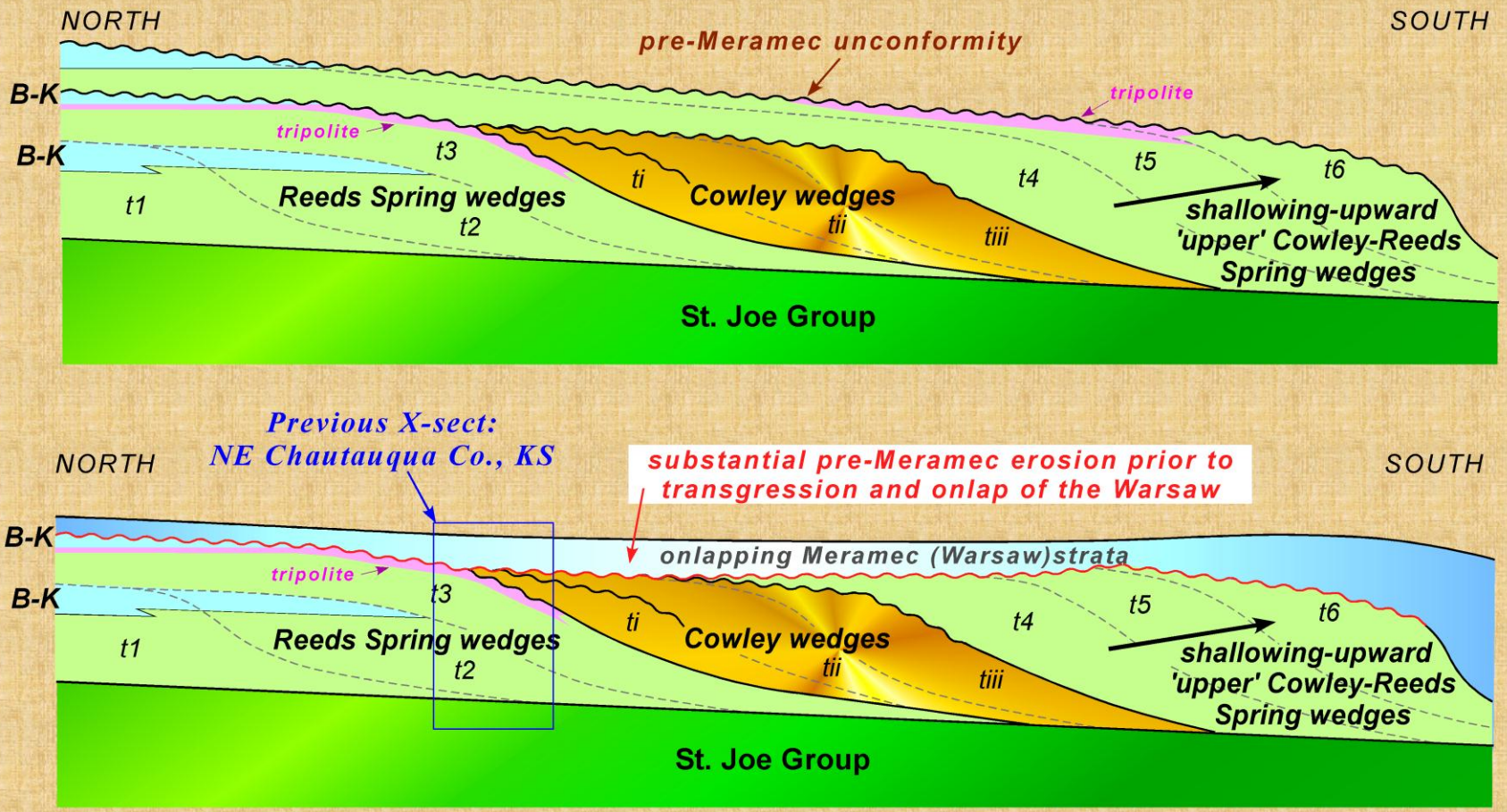


CORRECT!!!

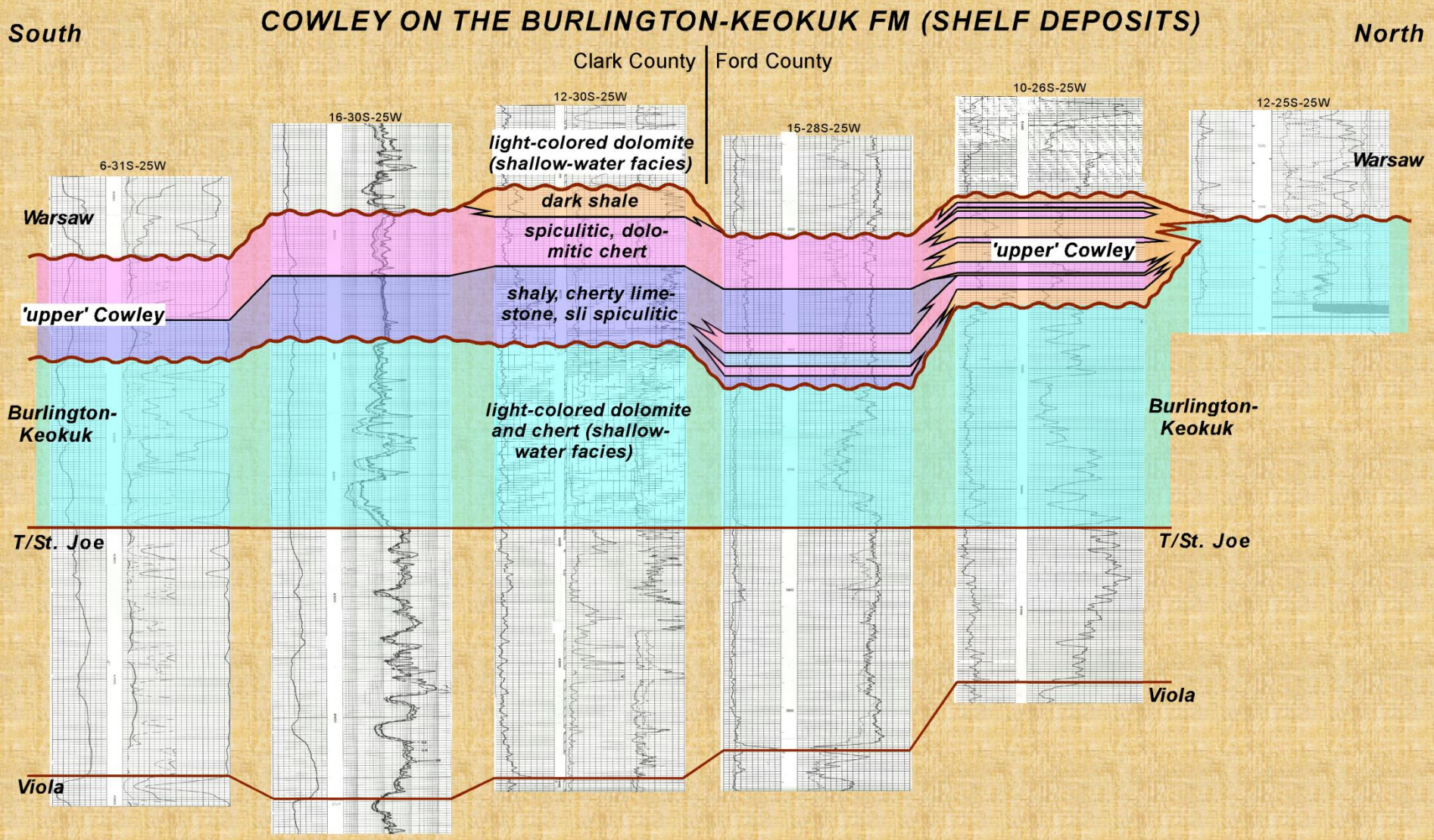
BASED ON LOG CORRELATION COUPLED WITH SAMPLE EXAMINATION



RECOGNITION OF THE COMPONENT LITHOSTRATIGRAPHIC UNITS AND THEIR BOUNDING UNCONFORMITIES ARE *KEY* TO UNDERSTANDING STRATAL STACKING PATTERNS AND RESERVOIRS DISTRIBUTION THEREIN.

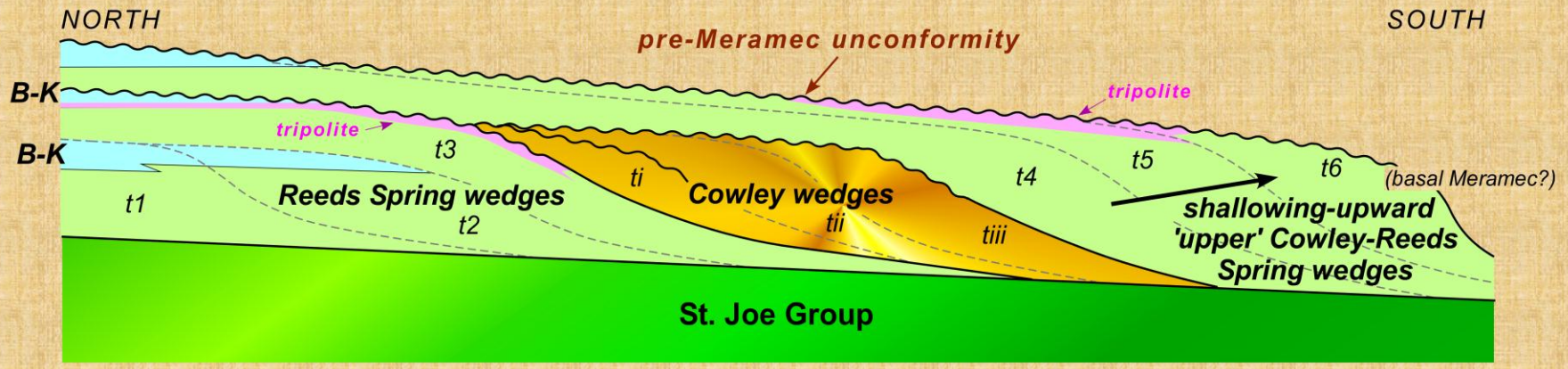


ANOTHER EXAMPLE OF COMPLEX STRATAL STACKING & DEPOSITIONAL ARCHITECTURE

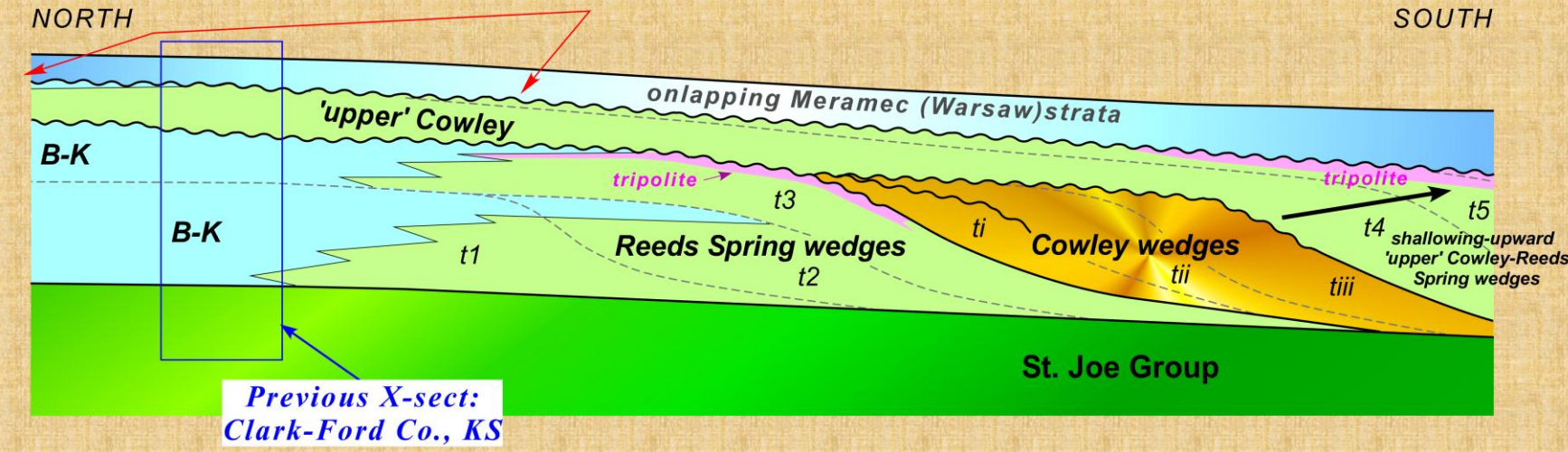


CLARK - FORD COUNTY EXAMPLE IN THE DEPOSITIONAL MODEL

SHELF MARGIN DEPOSITIONAL ARCHITECTURAL MODEL

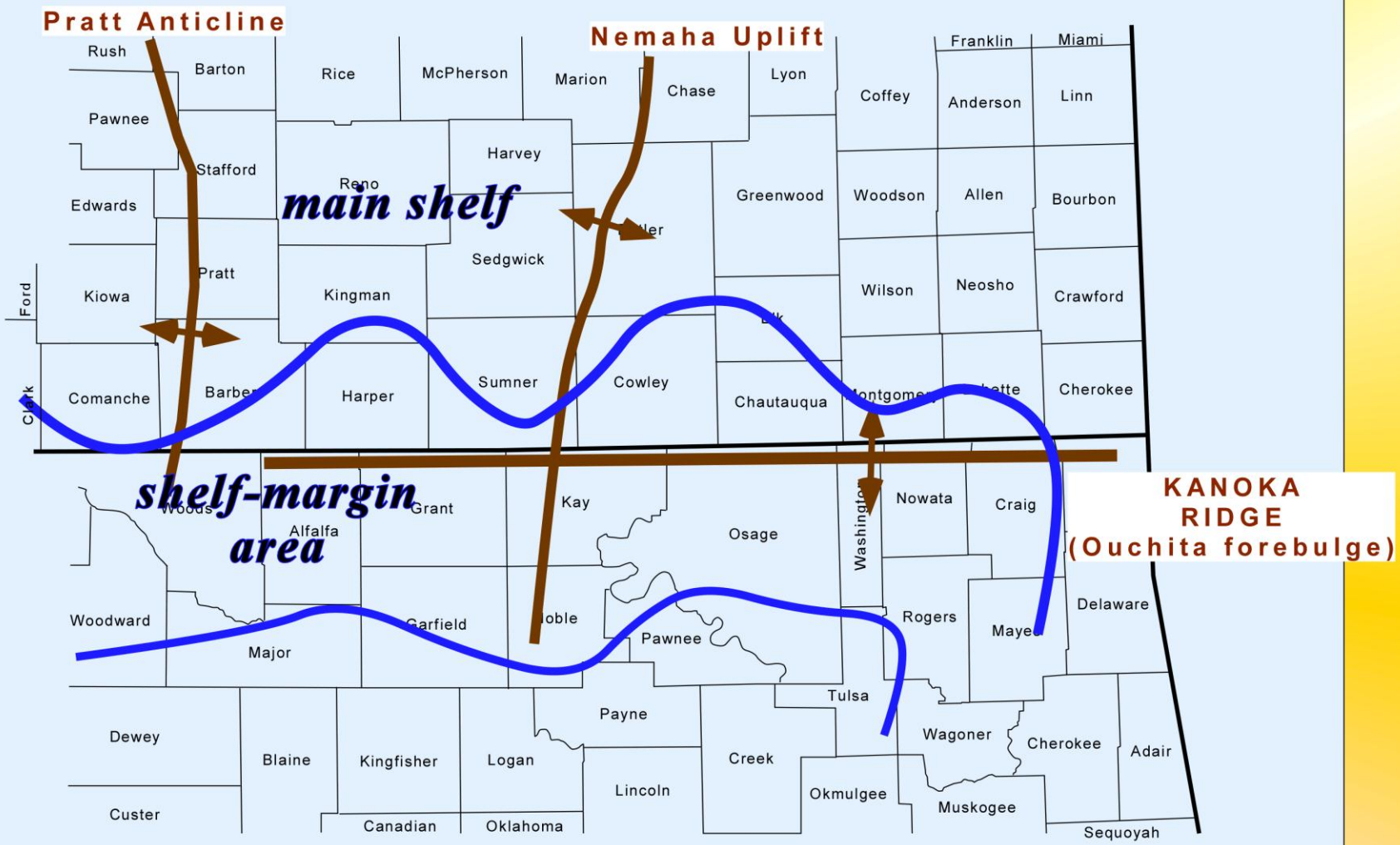


UPDIP, ONTO THE SHELF, IN THIS MODEL

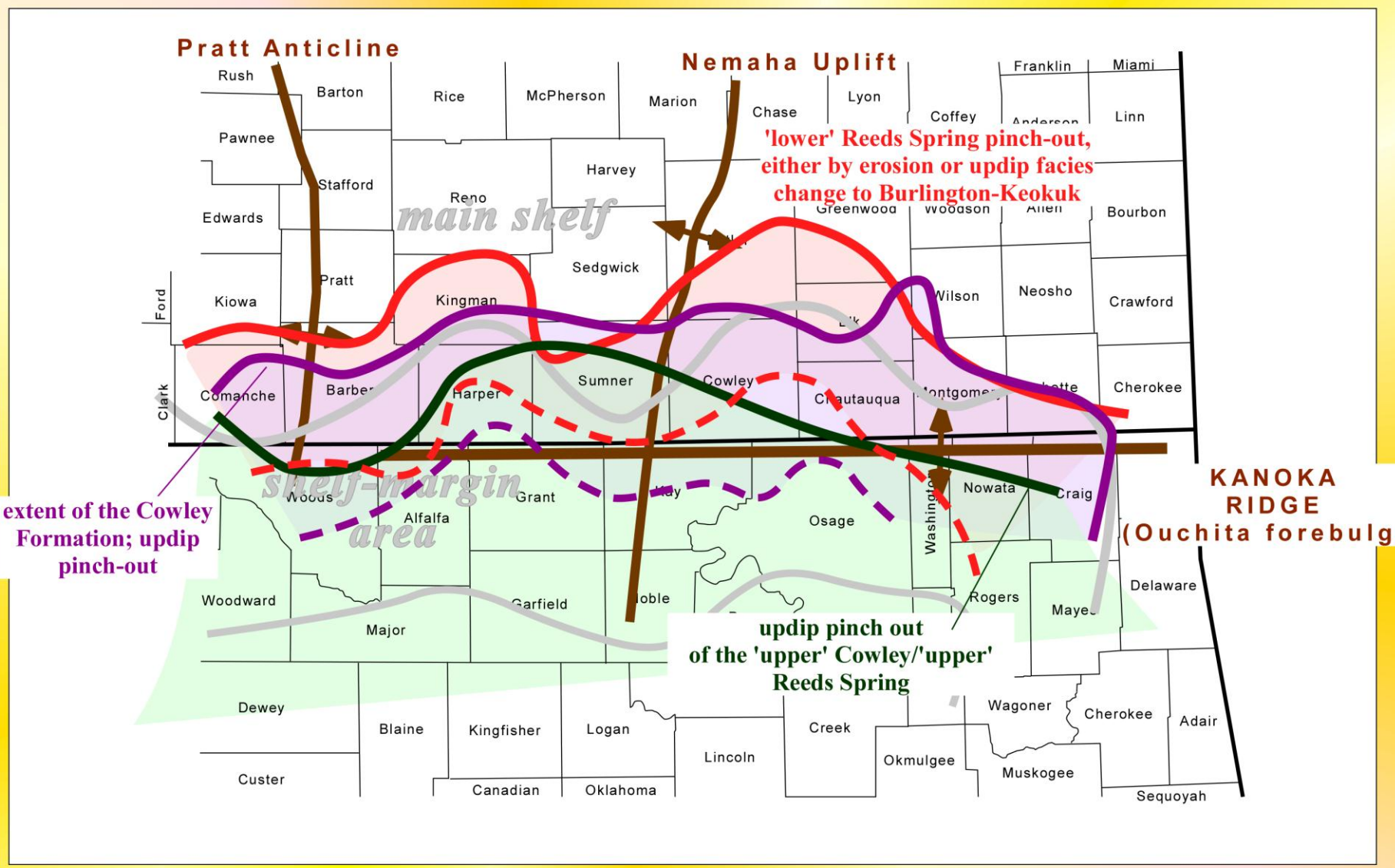


KNOWING YOUR POSITION ON THE SHELF/SHELF MARGIN IS PARAMOUNT IN UNDERSTANDING THESE STRATAL RELATIONS!!

PREDICTABILITY OF COMPONENT LITHOSTRATIGRAPHIC UNITS IS DEPENDENT ON POSITION ON THE SHELF AND....



PREDICTABILITY OF COMPONENT LITHOSTRATIGRAPHIC UNITS IS DEPENDENT ON POSITION ON THE SHELF AND....



MAPPED FACIES BOUNDARIES AND UNIT PINCH-OUTS

The complexity of the lithostratigraphic architecture of the subsurface is resolvable and can be identified, as shown, through:

1. identification/recognition of component lithostratigraphic units (and facies therein), particularly aided by cuttings and core analysis

2. recognition of sequence bounding unconformities

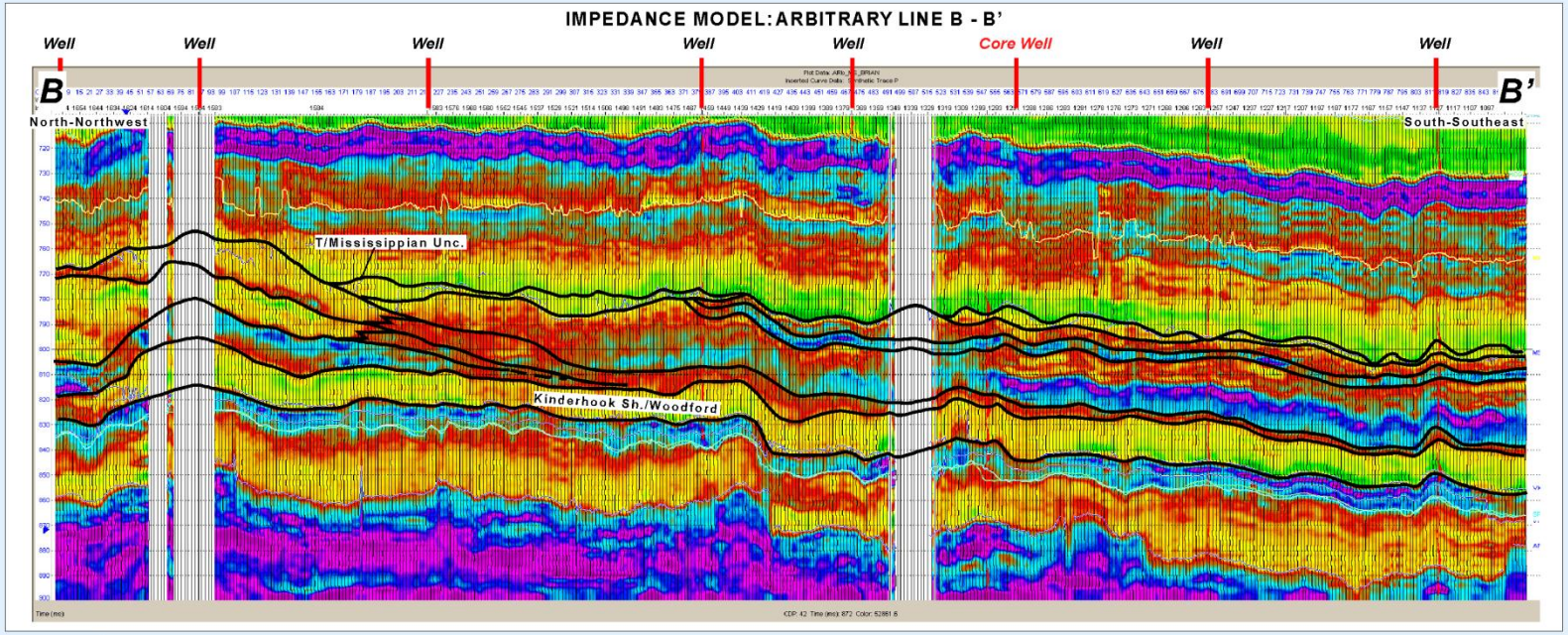
3. positioning in reference to the shelf / shelf margin

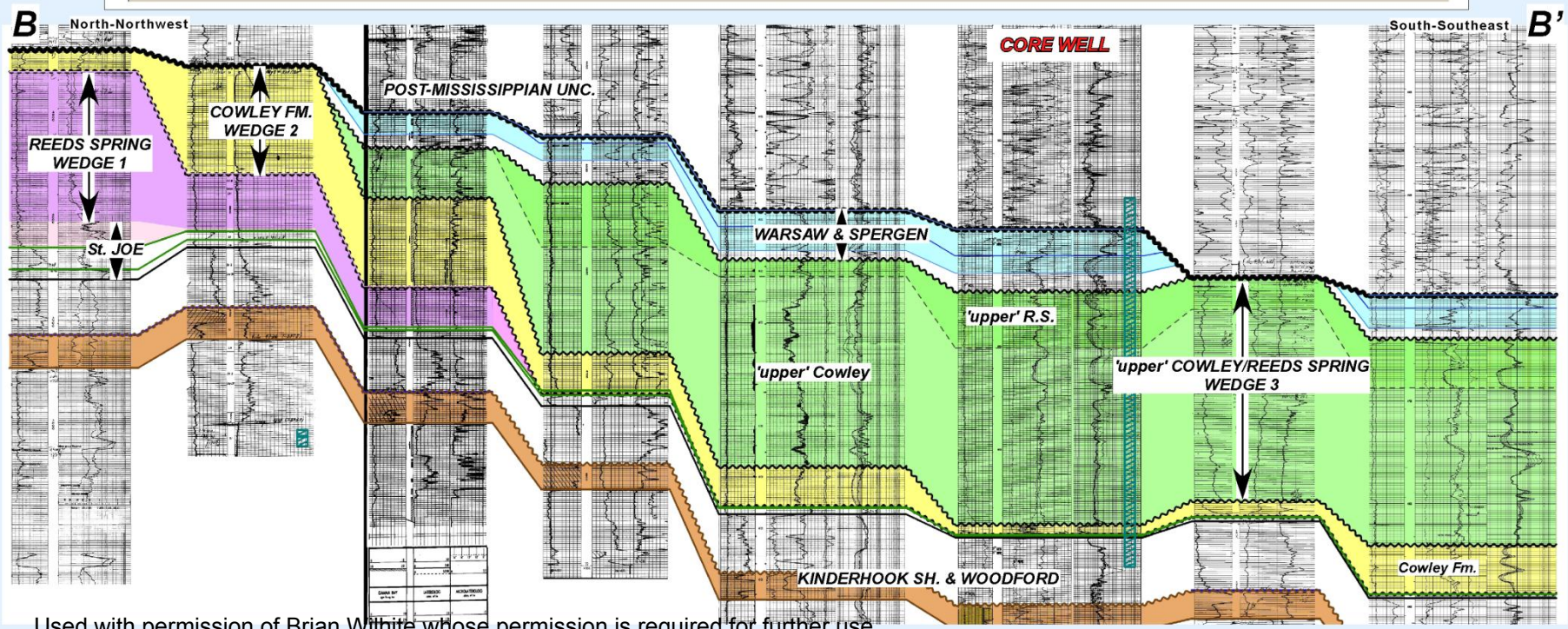
Subsurface correlations are attainable via these methods and furthermore, substantiated and resolved

SEISMICALLY

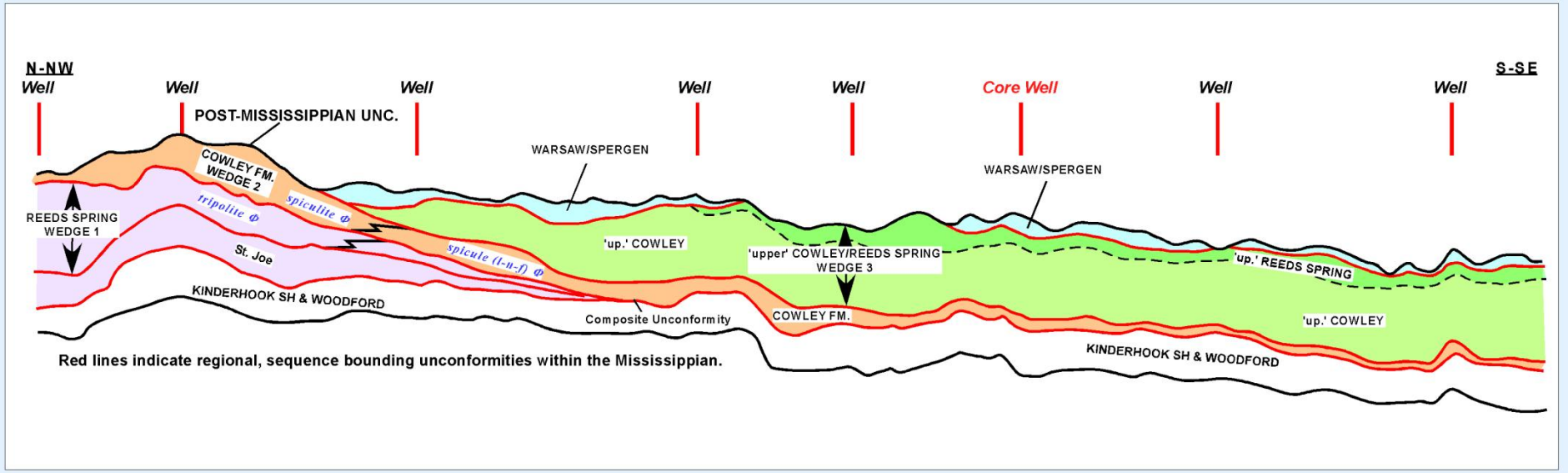
--- specifically through impedance modeling ---

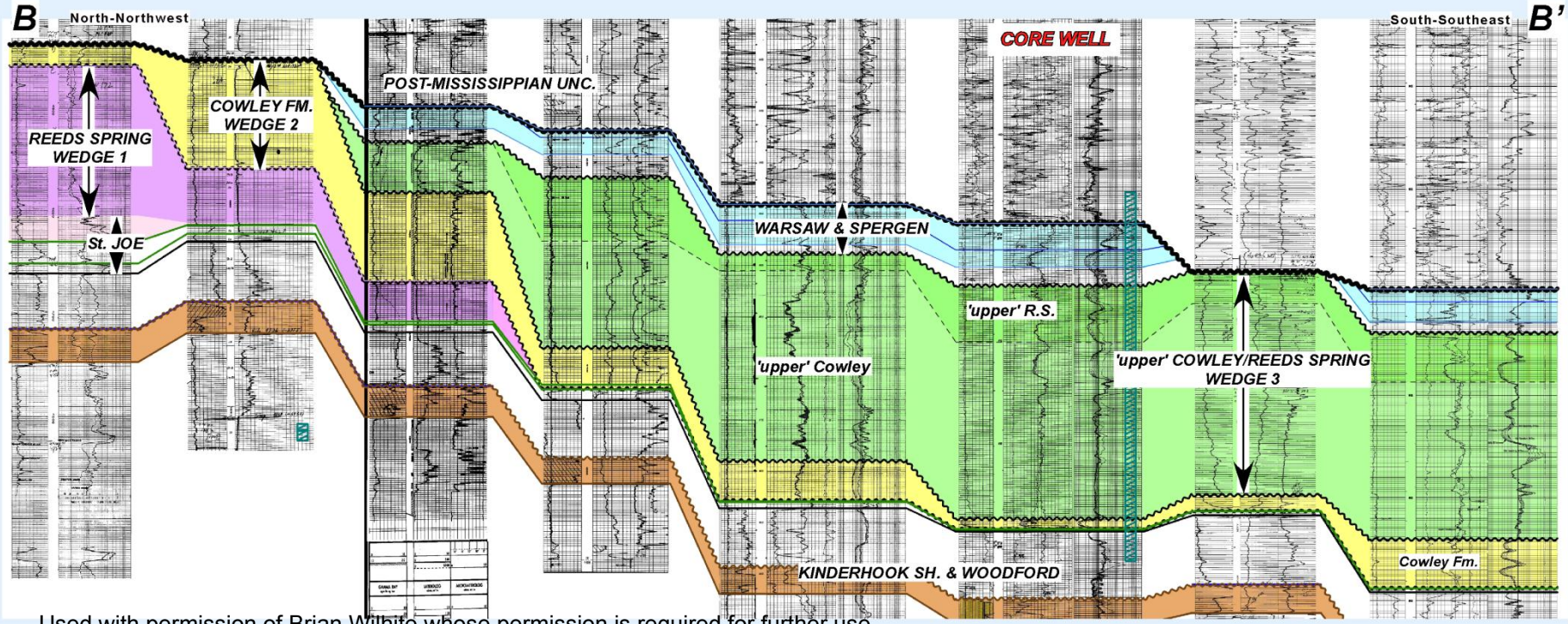
SEISMIC EXAMPLE 1: SOUTH-CENTRAL KANSAS



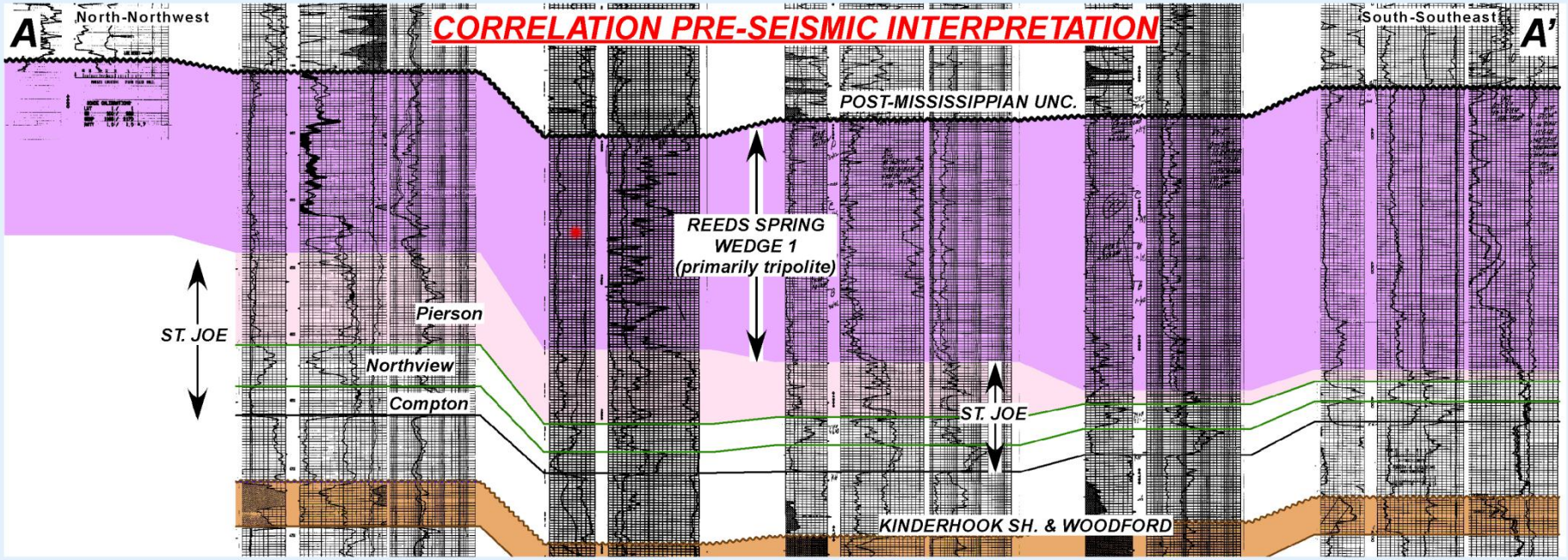


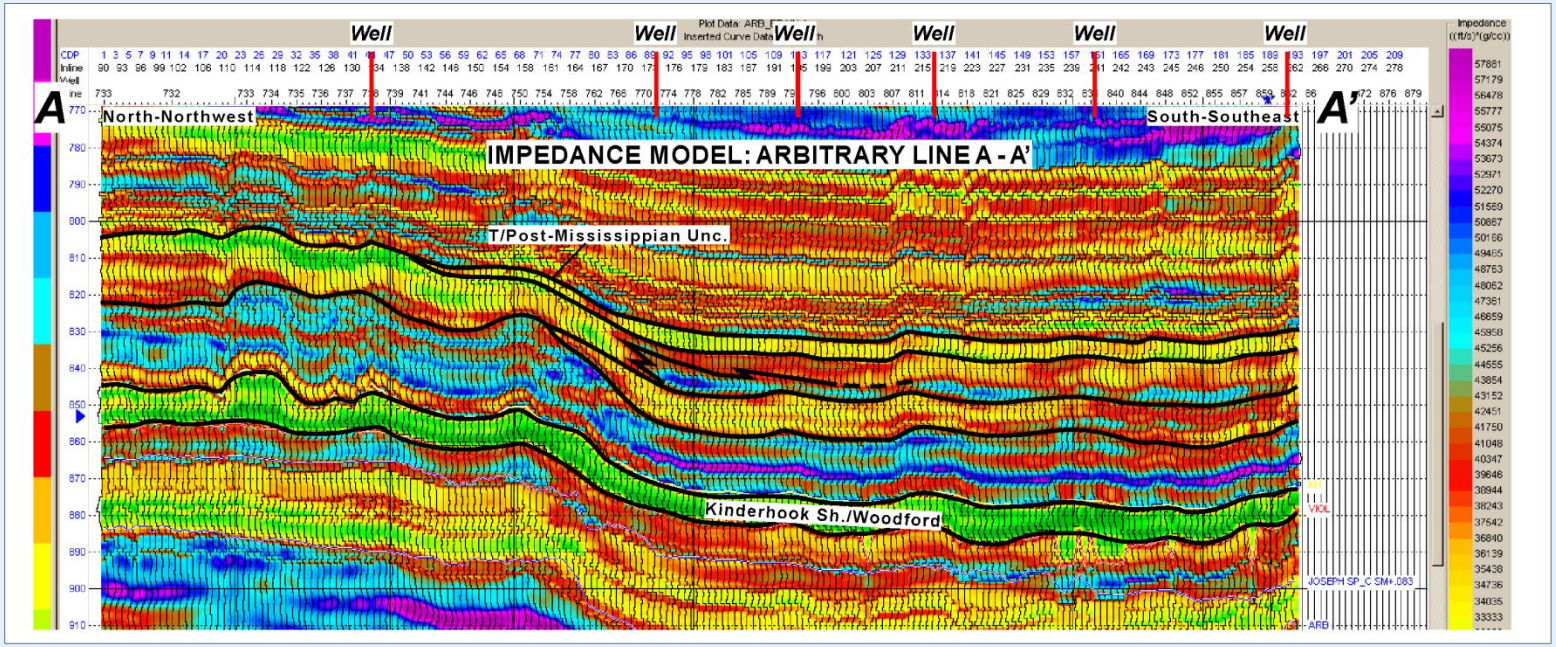
SEISMIC STRATIGRAPHY FROM IMPEDANCE MODEL
-- GOOD CORRELATION WITH LOGS --





SEISMIC EXAMPLE 2: SOUTH-CENTRAL KANSAS





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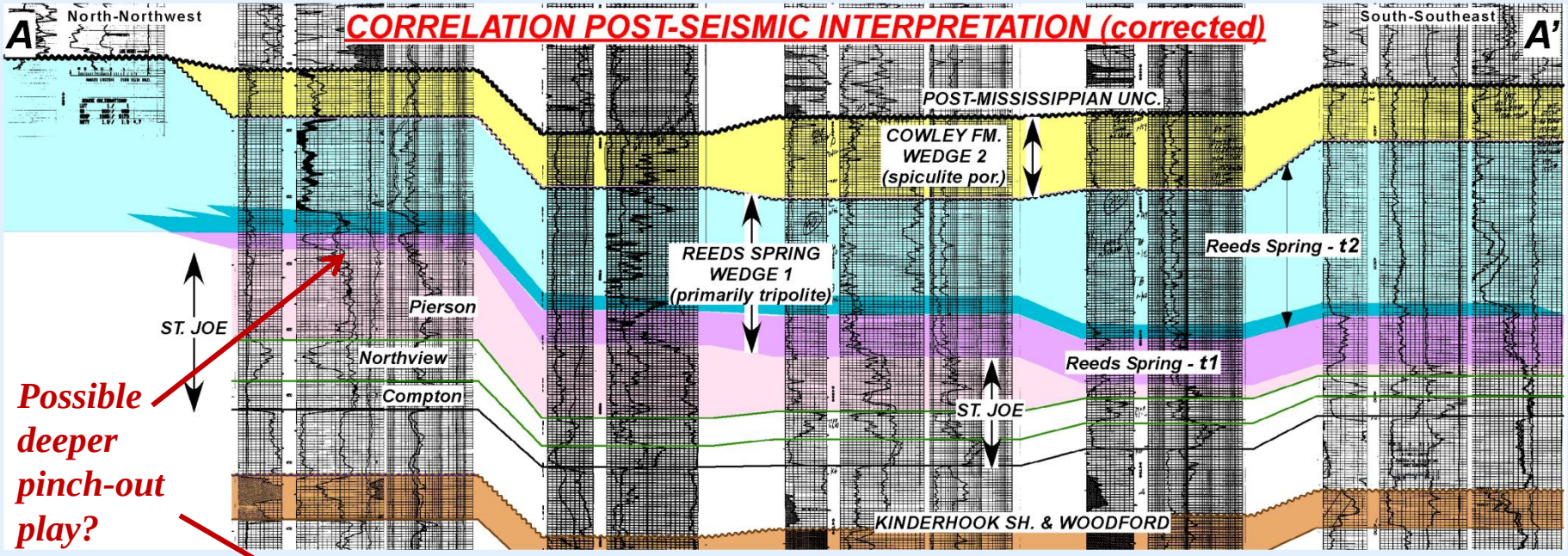
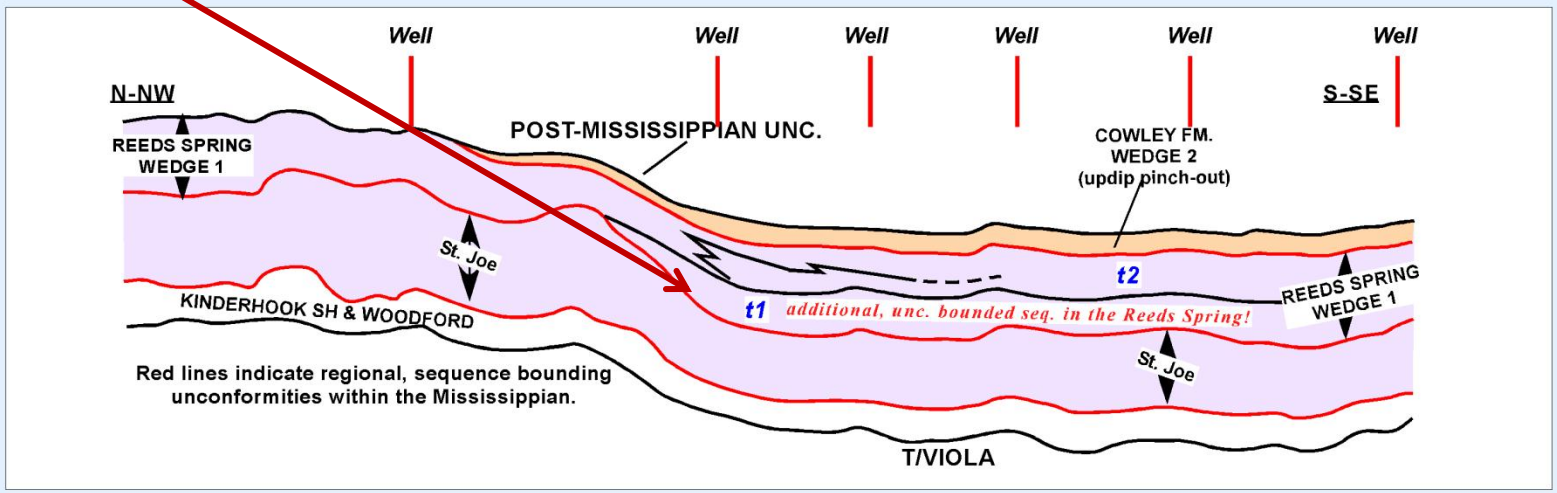
SEISMIC STRATIGRAPHY FROM IMPEDANCE MODEL

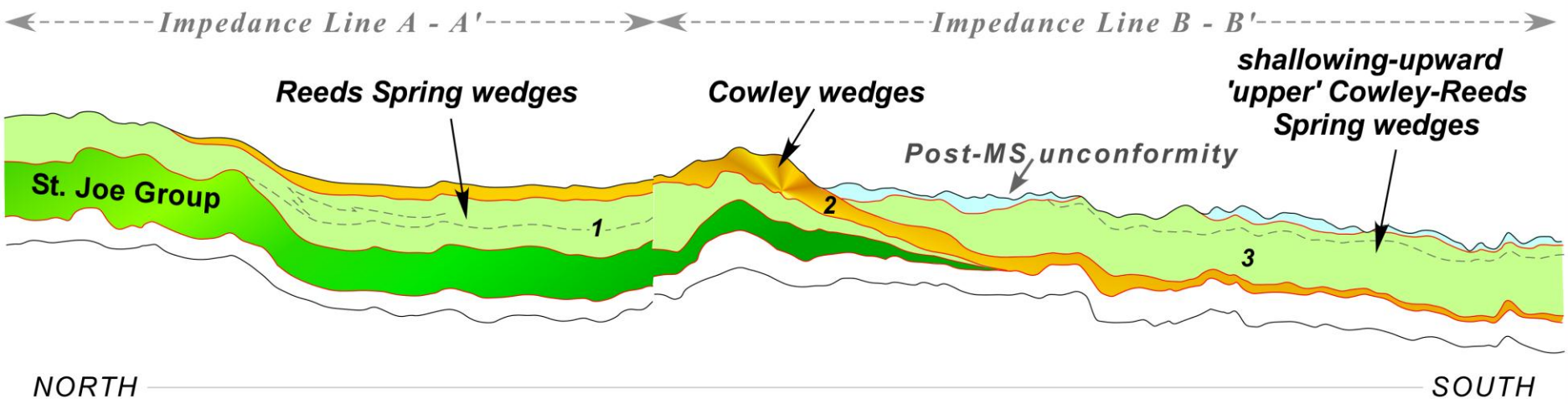




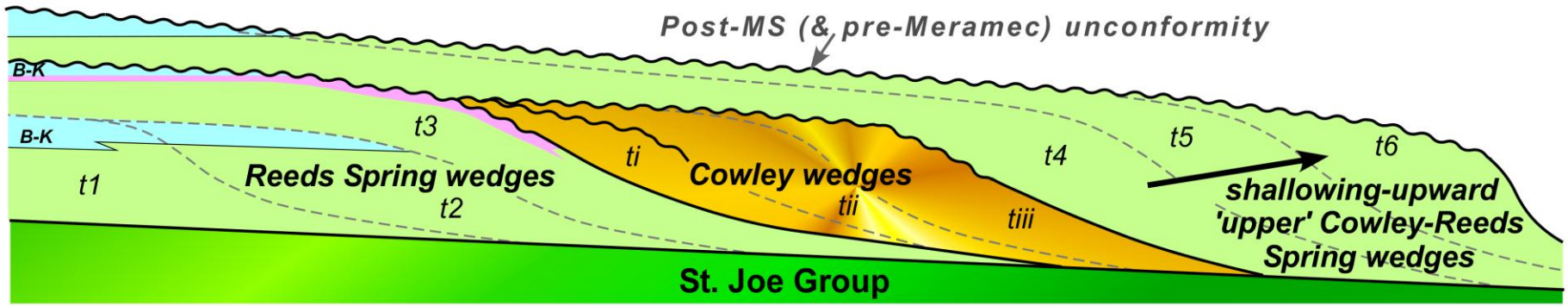
INTERPRETATION OF IMPEDANCE SECTIONS HAS YIELDED FURTHER UNDERSTANDING OF INTRA-MISSISSIPPIAN CORRELATIONS AS WELL AS CONFIRM (OR DENY) ORIGINAL SUBSURFACE CORRELATIONS.

LIFE IMITATES 'ART' IMITATES LIFE

SUBSURFACE STRATIGRAPHIC ARCHITECTURE AS DELINEATED ON SEISMIC



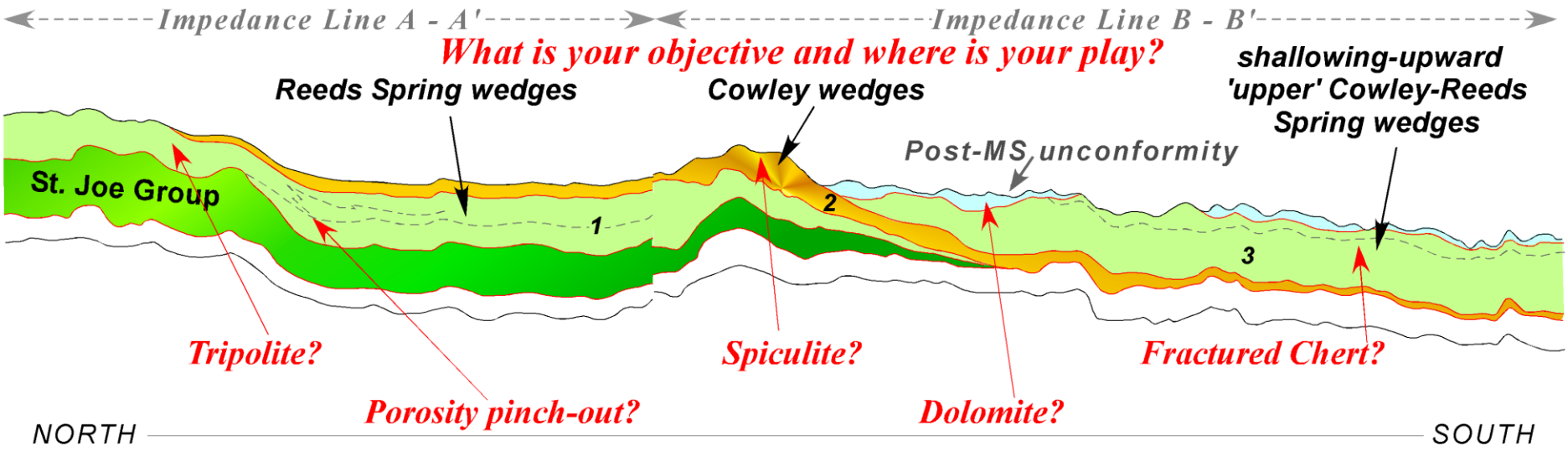
MODEL OF STRATIGRAPHIC ARCHITECTURE



Here is the reality of the subsurface as shown on seismic profile. The complexity illustrated confirms our models developed from the outcrop, sample analysis and log correlation.

KEY TO EXPLORATION ALONG THE SHELF MARGIN

SUBSURFACE STRATIGRAPHIC ARCHITECTURE AS DELINEATED ON SEISMIC



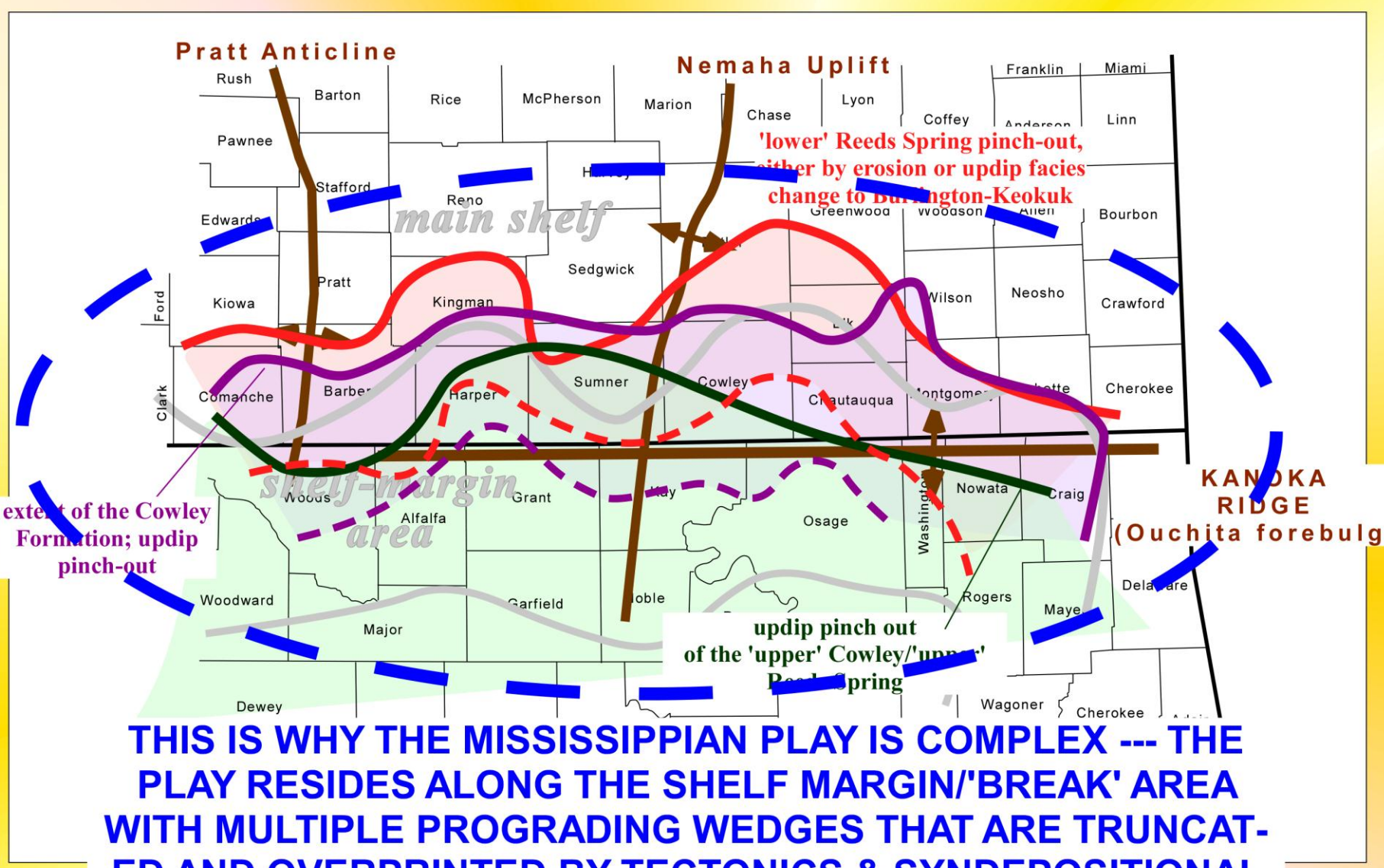
INASMUCH AS EACH COMPONENT LITHOSTRATIGRAPHIC UNIT ABOVE CONTAINS DIFFERENT PETROLEUM SYSTEMS AND RESERVOIRS

---EACH WITH UNIQUE PETROPHYSICS---
(*AS WAS ADDRESSED IN THE PREVIOUS TALK)

IT IS PARAMOUNT TO BE ABLE TO RECOGNIZE THESE UNITS

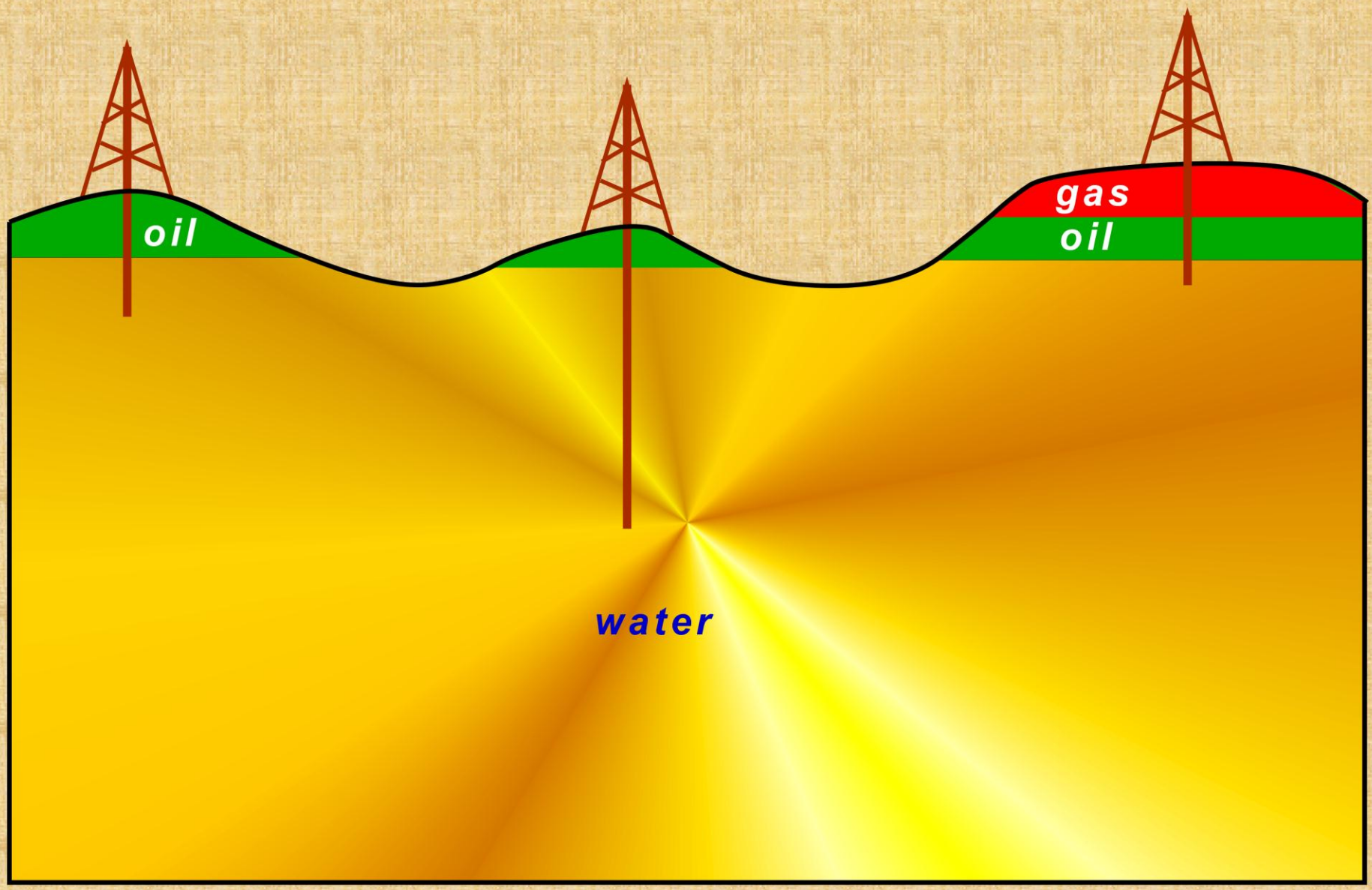
---THEIR GEOMETRIES, DISTRIBUTION AND STACKING PATTERNS---

ON SEISMIC AND IN THE SUBSURFACE.



THIS IS WHY THE MISSISSIPPIAN PLAY IS COMPLEX --- THE PLAY RESIDES ALONG THE SHELF MARGIN/'BREAK' AREA WITH MULTIPLE PROGRADING WEDGES THAT ARE TRUNCAT-ED AND OVERPRINTED BY TECTONICS & SYNDEPOSITIONAL TECTONICS.....

THIS IS NOT WHAT THE MISS IS:



CONCLUSIONS:

* The Mississippian/Mississippian Play is ***not*** a 'Lime' play consisting of a single unit or objective; nor, is it a "blanket deposit" with erratic lithologic changes.

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* The Mississippian ***is*** inherently complex in its lithostratigraphic architecture of which, is further complicated by syndepositional and pre-Cherokee tectonics.

---

* HOWEVER, the Mississippian lithostratigraphic architecture, and reservoir objectives therein, ***ARE PREDICTABLE*** through...

- recognition of component lithostratigraphic units via cuttings and core analysis;
- identification of these units on log cross-sections and delineating sequence bounding unconformities;
- knowledge of position on the shelf;
- mapping unit updip and downdip pinchouts and extents;
- seismic impedance modeling i.e., recognition of onlapping, downlapping and porgradational geomtetries;

---

* In this approach, component petroleum systems and reservoir objectives can be readily identified, within the Mississippian System.