Mississippian Oil Reservoirs in the Southern Midcontinent: New Exploration Concepts for a Mature Reservoir Objective*

S.J. Mazzullo[1]

Search and Discovery Article #10373 (2011)
Posted November 28, 2011

*Adapted from oral presentation given at the Tulsa Geological Society luncheon, October 11, 2011
S. J. Mazzullo delivered this presentation representing his co-workers and co-authors Brian W. Wilhite and Beau T.Morris.

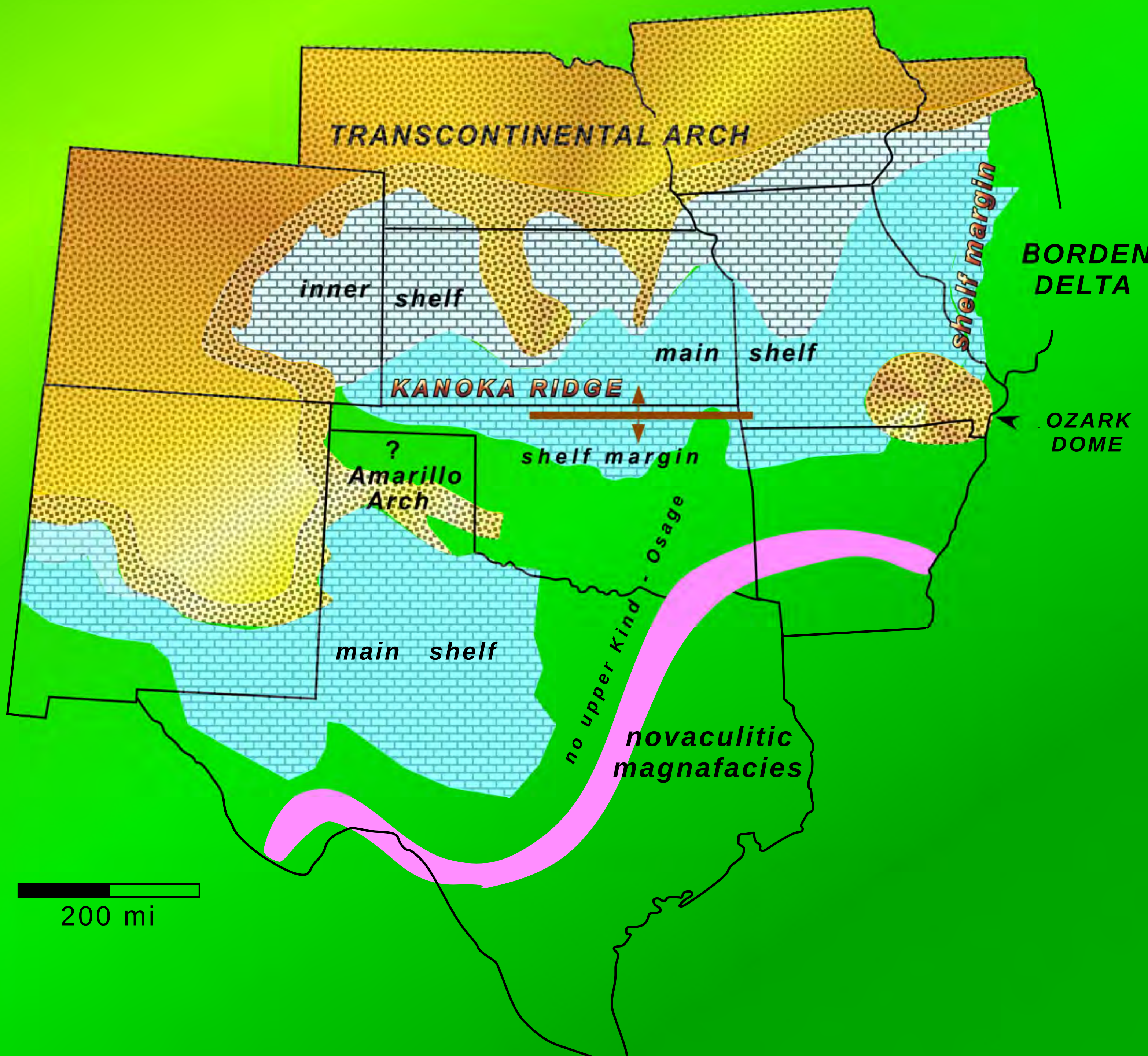
[1]Wichita State University, Wichita, KS; Mazzullo Exploration, LLC (sjmazzullo@gmail.com)

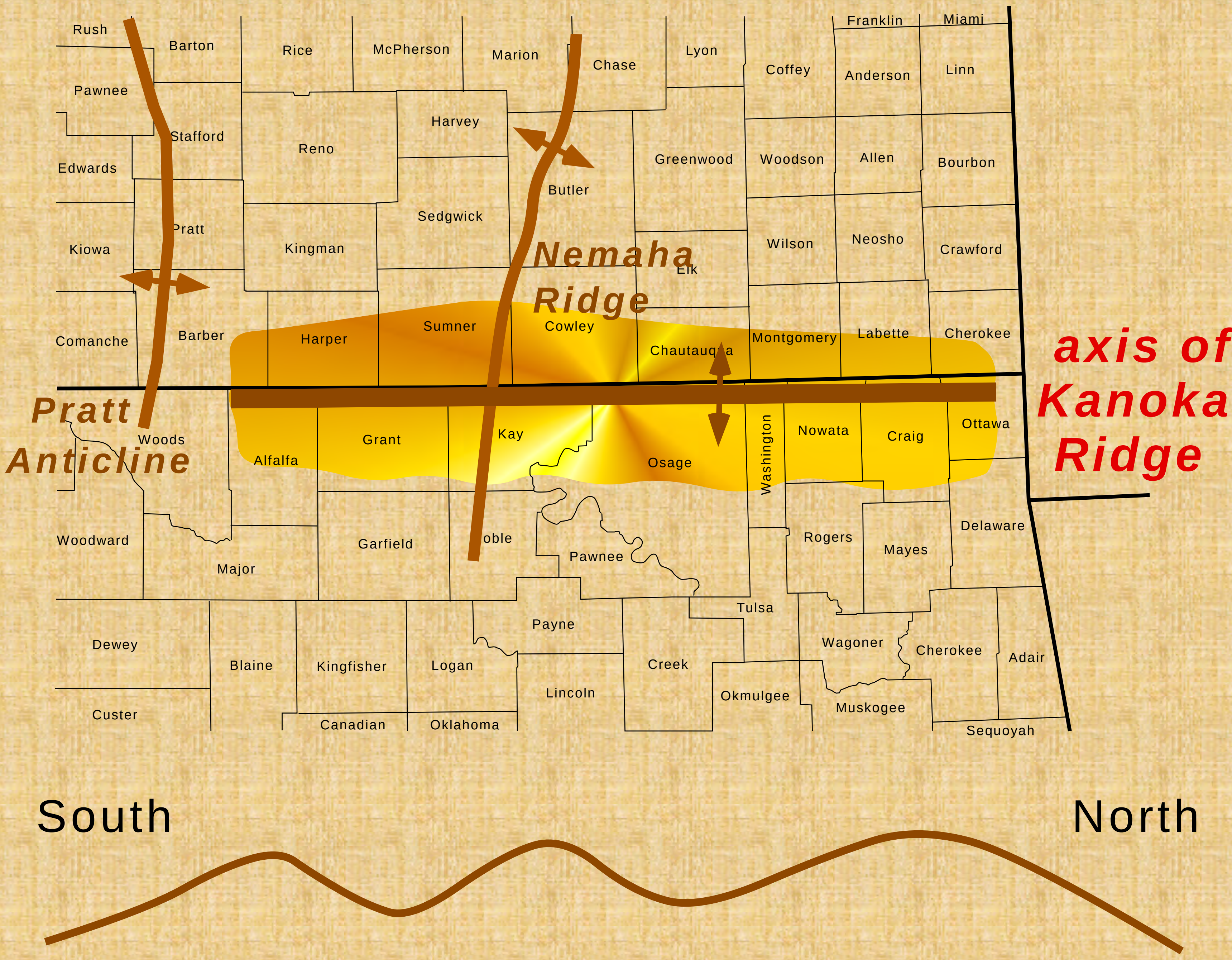
Abstract

The Mississippian has been a long sought-after reservoir objective in Kansas and Oklahoma, where it has produced several billion barrels of oil since early in the 20th century. Despite hundreds of thousands of wells having been drilled throughout these states into these rocks, their stratigraphy and fundamental controls on reservoir occurrence have remained elusive, enigmatic, and confusing for decades. Recent studies of outcrops of Lower Mississippian (Kinderhookian and Osagean) rocks in Missouri, Arkansas, and Oklahoma have clarified the lithostratigraphy and sequence stratigraphy of the section and have resulted in the generation of stratigraphic and structural exploration models that are directly applicable to the subsurface. Continued study and exploration of these rocks in the subsurface have further clarified regional lithostratigraphic relationships and have resulted in the identification of several hot, new plays that currently are the object of intense leasing and exploration throughout Kansas and Oklahoma. Such plays may very well extend into central and west Texas. In this article I illustrate what we have learned about the Lower Mississippian from outcrop studies, how outcrop models pertain to subsurface exploration, and describe the new Mississippian plays and their possible extension into Texas.


MISSISSIPPIAN OIL RESERVOIRS IN THE SOUTHERN MIDCONTINENT: NEW EXPLORATION CONCEPTS FOR A MATURE RESERVOIR OBJECTIVE
S. J. Mazzullo
Wichita State University &
Petroleum Geological Consultant

REVISED REGIONAL PALEOFACIES MODEL

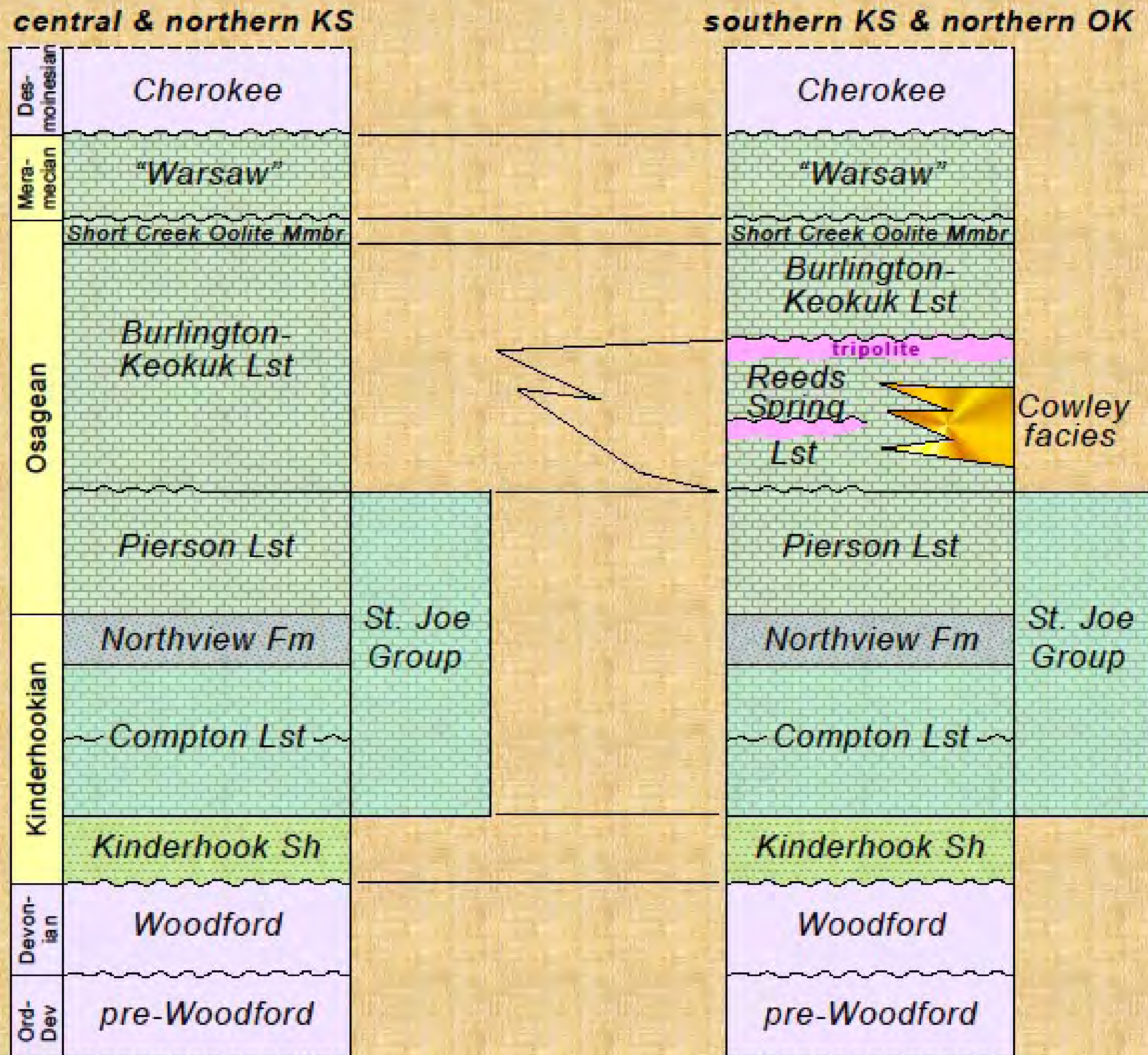




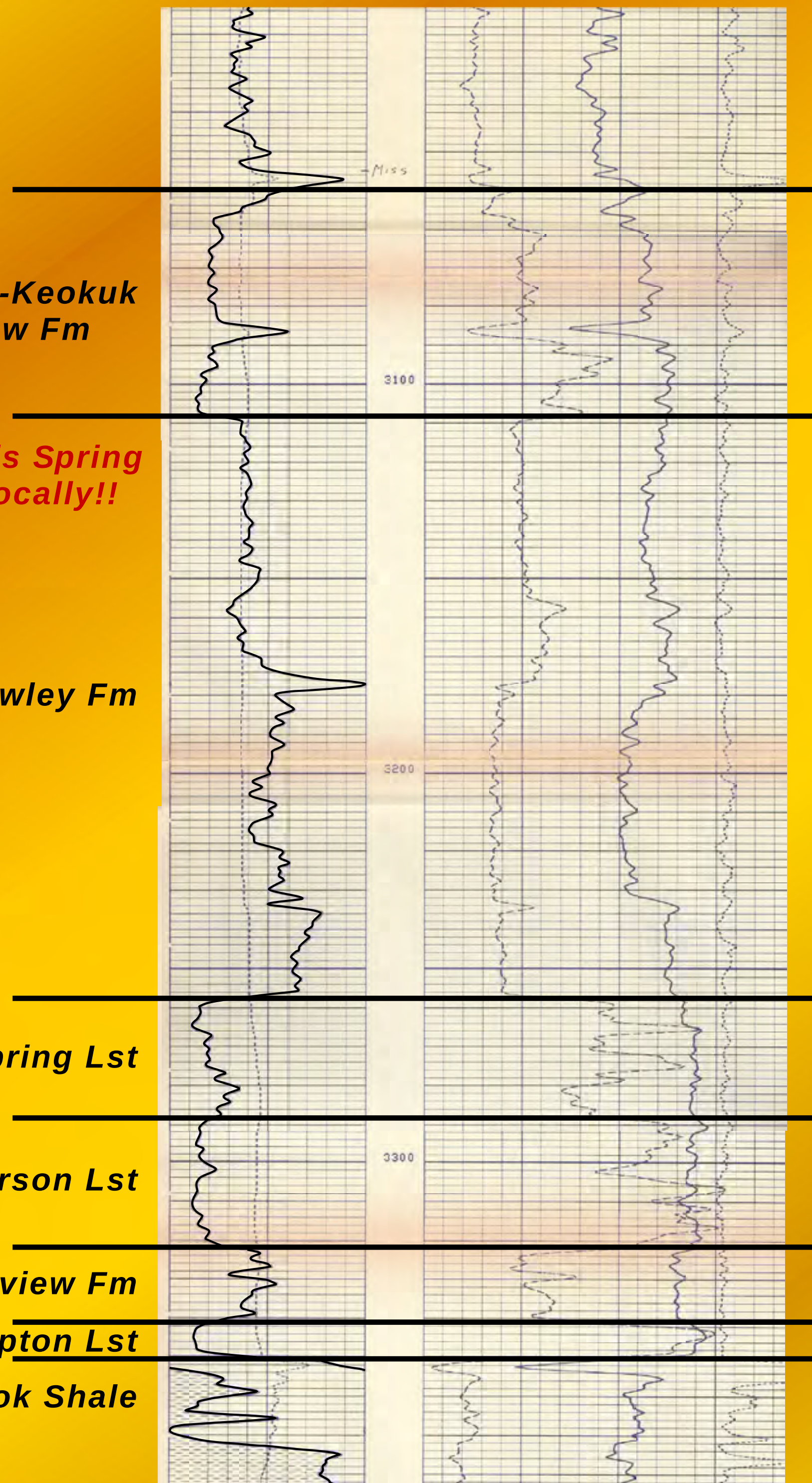
Rush
Barton
Rice
McPherson
Marion
Chase
Lyon
Coffey
Franklin
Miami
Anderson
Linn
Pawnee
Stafford
Reno
Harvey
Edwards
Greenwood
Woodson
Allen
Bourbon
Butler
Sedgwick
Pratt
Kiowa
Kingman
Wilson
Neosho
Crawford
Nemaha
Ridge
Elk
Comanche
Barber
Harper
Sumner
Cowley
Chautauqua
Montgomery
Labette
Cherokee
axis of
Kanoka
Ridge
Pratt
Anticline
Woods
Alfalfa
Grant
Kay
Osage
Washington
Nowata
Craig
Ottawa
Woodward
Major
Garfield
Noble
Pawnee
Rogers
Mayes
Delaware
Dewey
Blaine
Kingfisher
Logan
Payne
Tulsa
Creek
Wagoner
Cherokee
Adair
Custer
Canadian
Oklahoma
Lincoln
Okmulgee
Muskogee
Sequoyah
South
North


LAURUSSIA
Transcontinental Arch
equator
CO
KS
MO
NM
OK
ARK
TX
Anadarko Basin
GONDWANA
area of volcanic activity during the Mississippian
Caballos-Arkansas chert island chain

SUBSURFACE STRATIGRAPHY



TYPE LOG, SOUTH-CENTRAL KANSAS



Burlington-Keokuk or Warsaw Fm

Reeds Spring Lst locally!!

Cowley Fm

Reeds Spring Lst

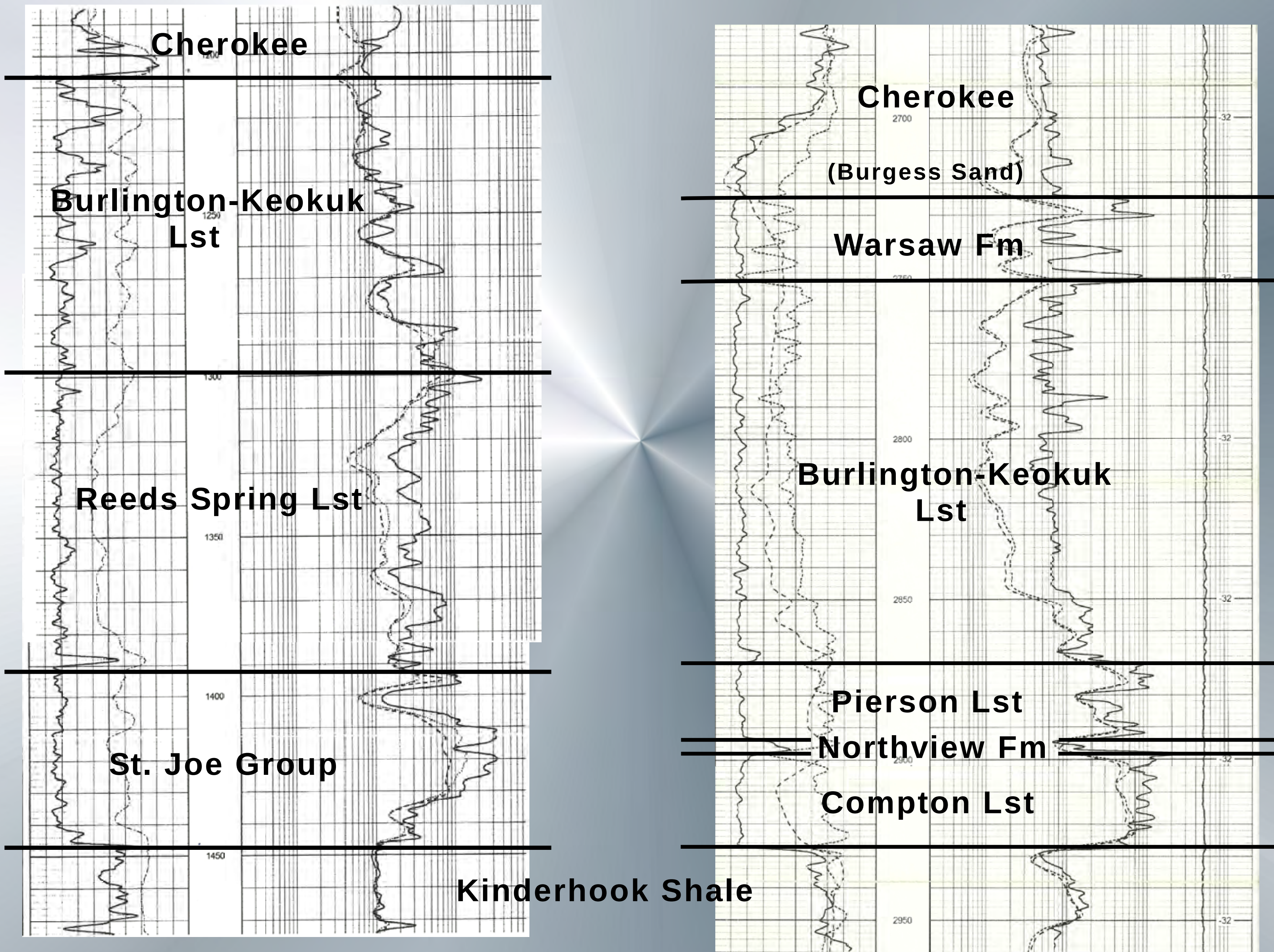
Pierson Lst

Northview Fm

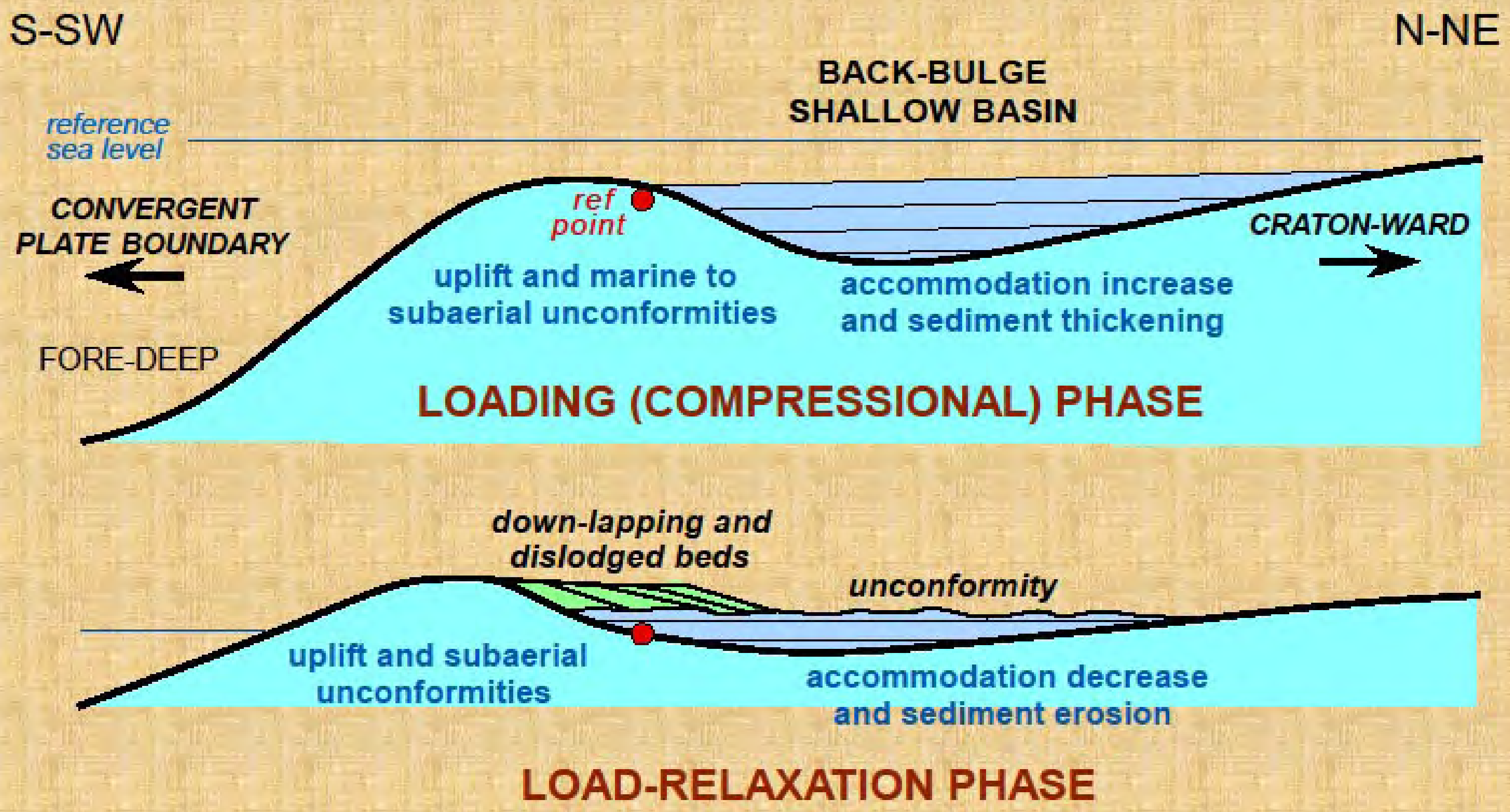
Compton Lst

Kinderhook Shale

OTHER TYPE LOGS



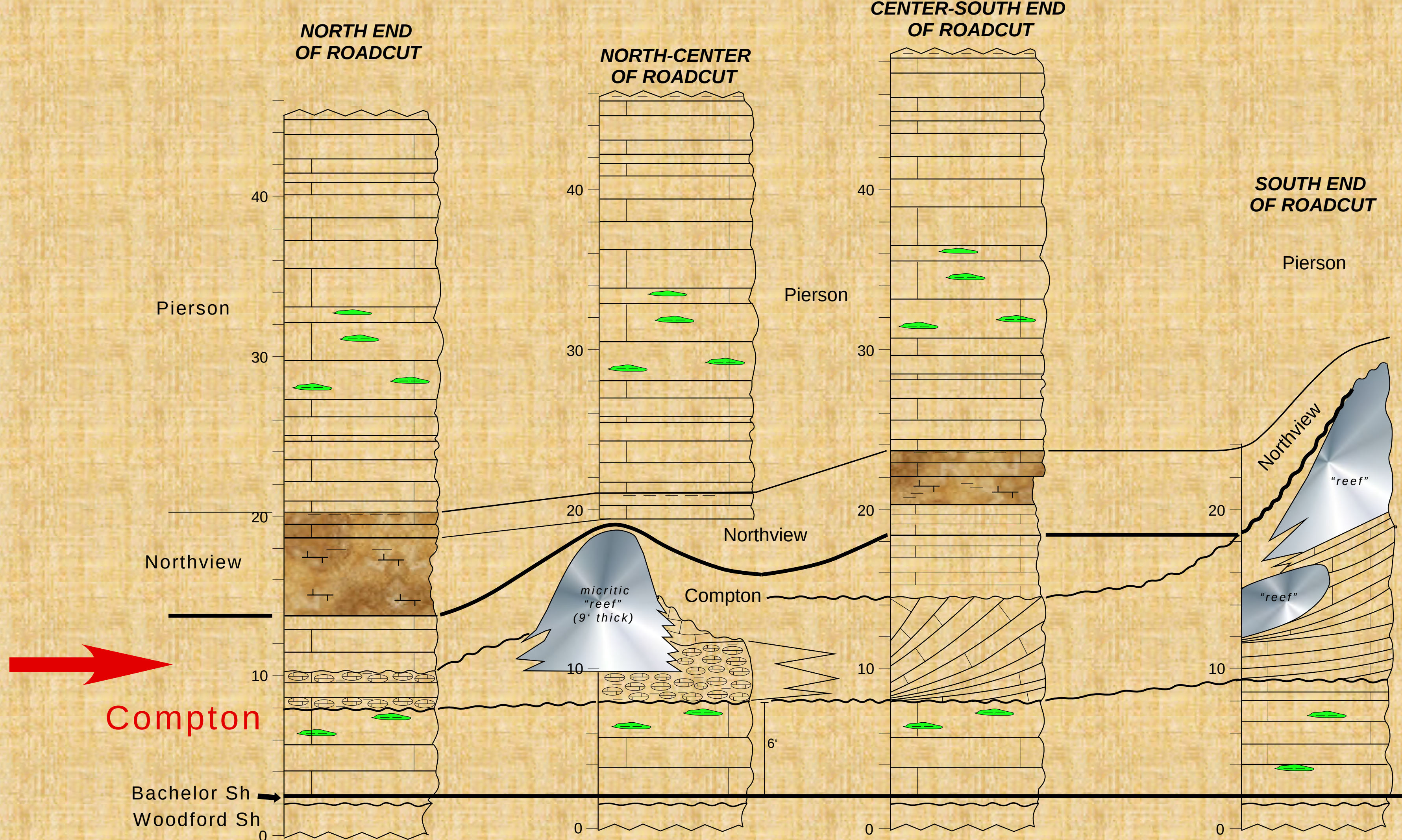
FORE-BULGE TECTONICS MODEL



LITHOSTRATIGRAPHIC REFLECTION OF SYNDEPOSITIONAL TECTONISM

- ***Northward dipping, resedimented limestones in the Compton, including reefs***

PROBABLY NOT MAJOR EXPLORATION OBJECTIVES



tectonically-displaced, northward downlapping beds with displaced reefs

tectonically-displaced, northward downlapping beds with larger displaced reefs

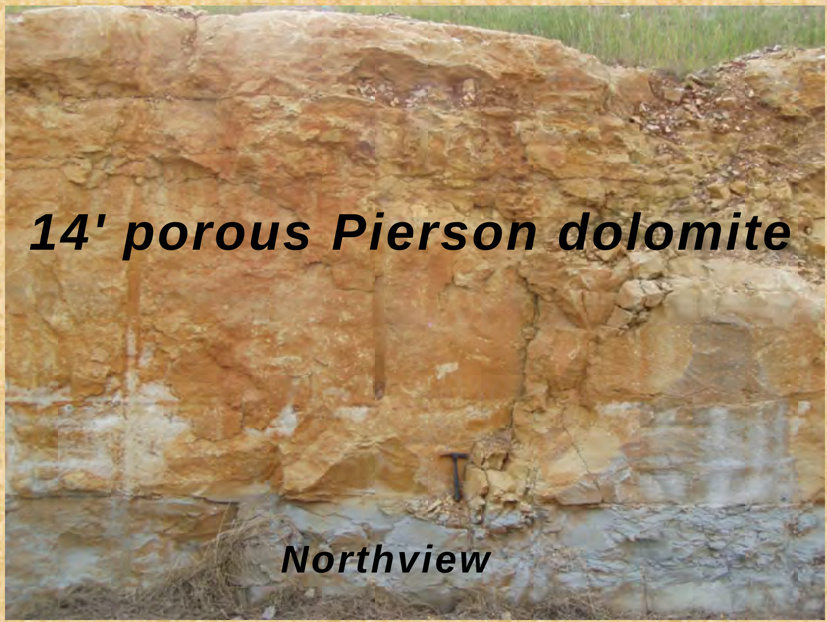
LITHOSTRATIGRAPHIC REFLECTION OF SYNDEPOSITIONAL TECTONISM

- ***Northward dipping, resedimented limestones in the Compton, including reefs***

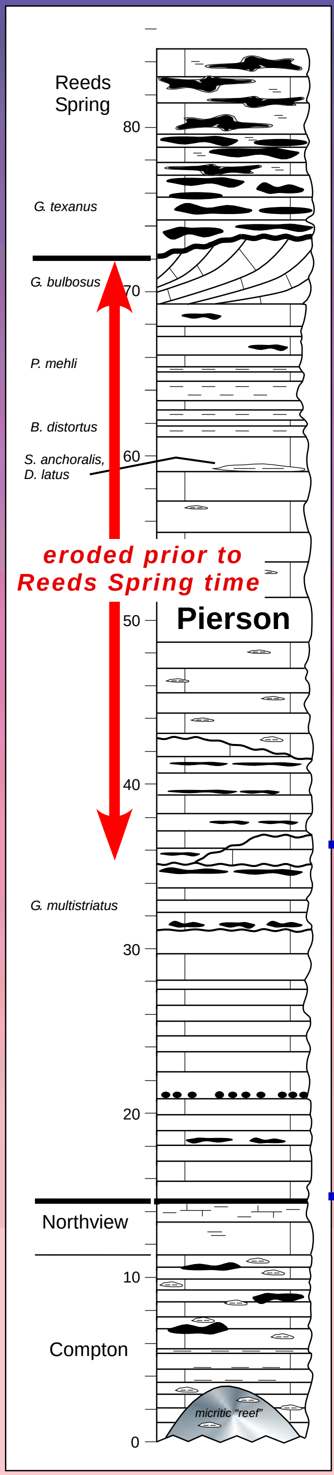
  PROBABLY NOT MAJOR EXPLORATION OBJECTIVES

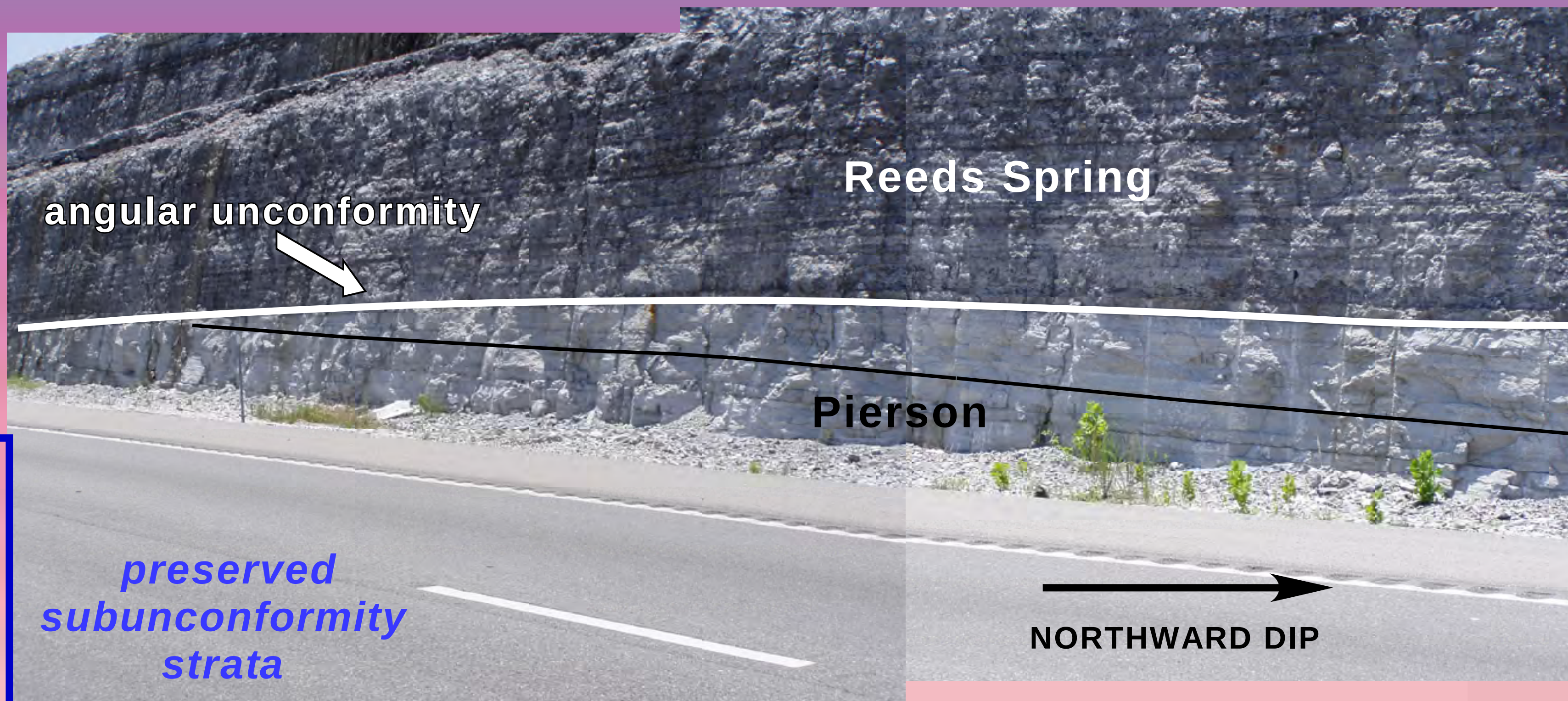
- ***Northward dipping Pierson Fm carbonates (limestones and dolomites) that are erosionally truncated along the north side of the Kanoka Ridge***

  LIKELY EXPLORATION OBJECTIVE



EROSION OF UPPER PIERSON ON LOCAL SYNDEPOSITIONAL HIGHS, HIGHWAY 71, SW MISSOURI





LITHOSTRATIGRAPHIC REFLECTION OF SYNDEPOSITIONAL TECTONISM

- ***Northward dipping, resedimented limestones in the Compton, including reefs***

  PROBABLY NOT MAJOR EXPLORATION OBJECTIVES

- ***Northward dipping Pierson Fm carbonates (limestones and dolomites) that are erosionally truncated along the north side of the Kanoka Ridge***

  LIKELY EXPLORATION OBJECTIVE

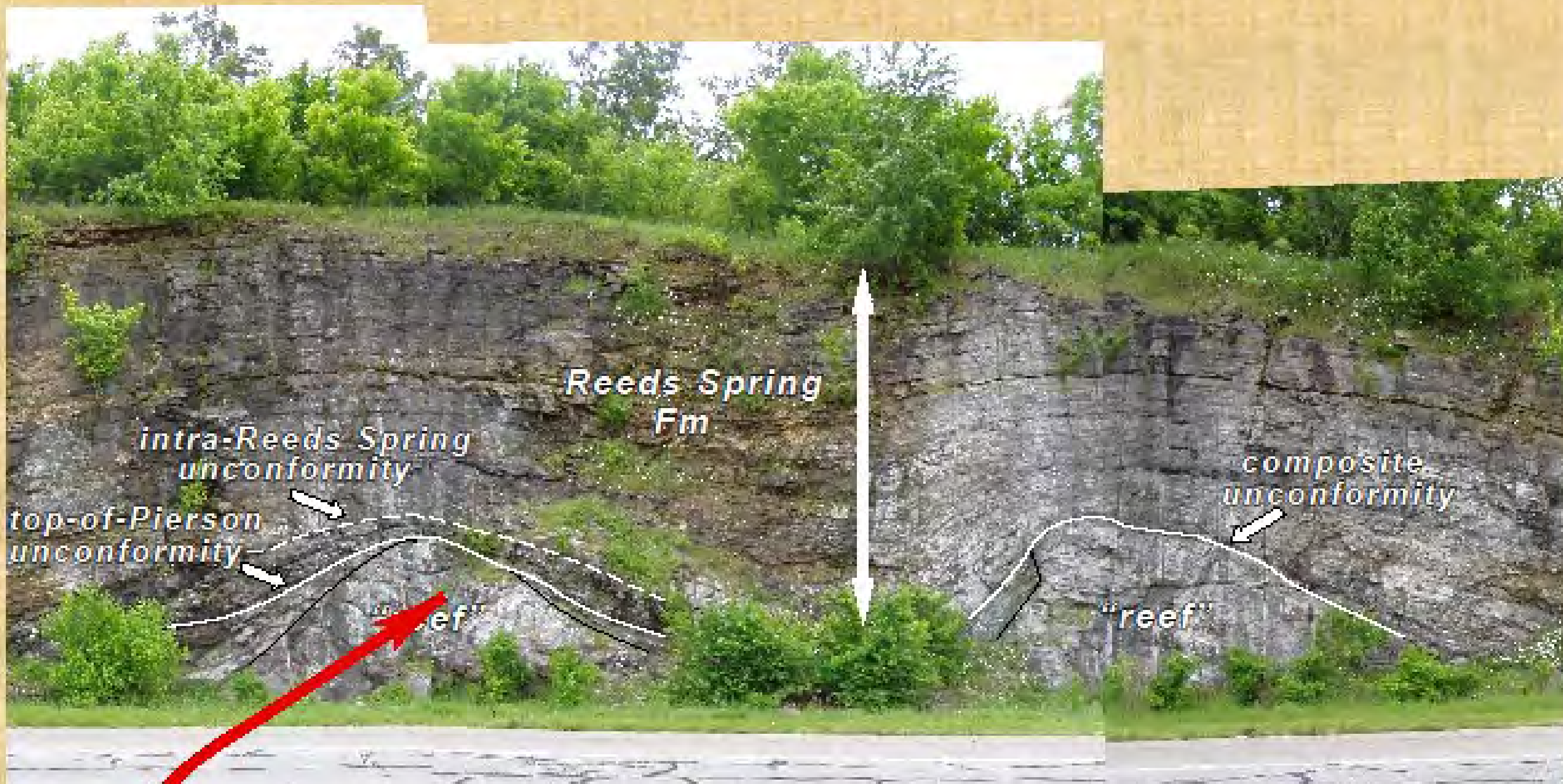
- ***In-place reefs in the Compton and Pierson Formations (which locally are oil-stained or oil-saturated on the outcrop***

  LIKELY EXPLORATION OBJECTIVES

Compton Reefs

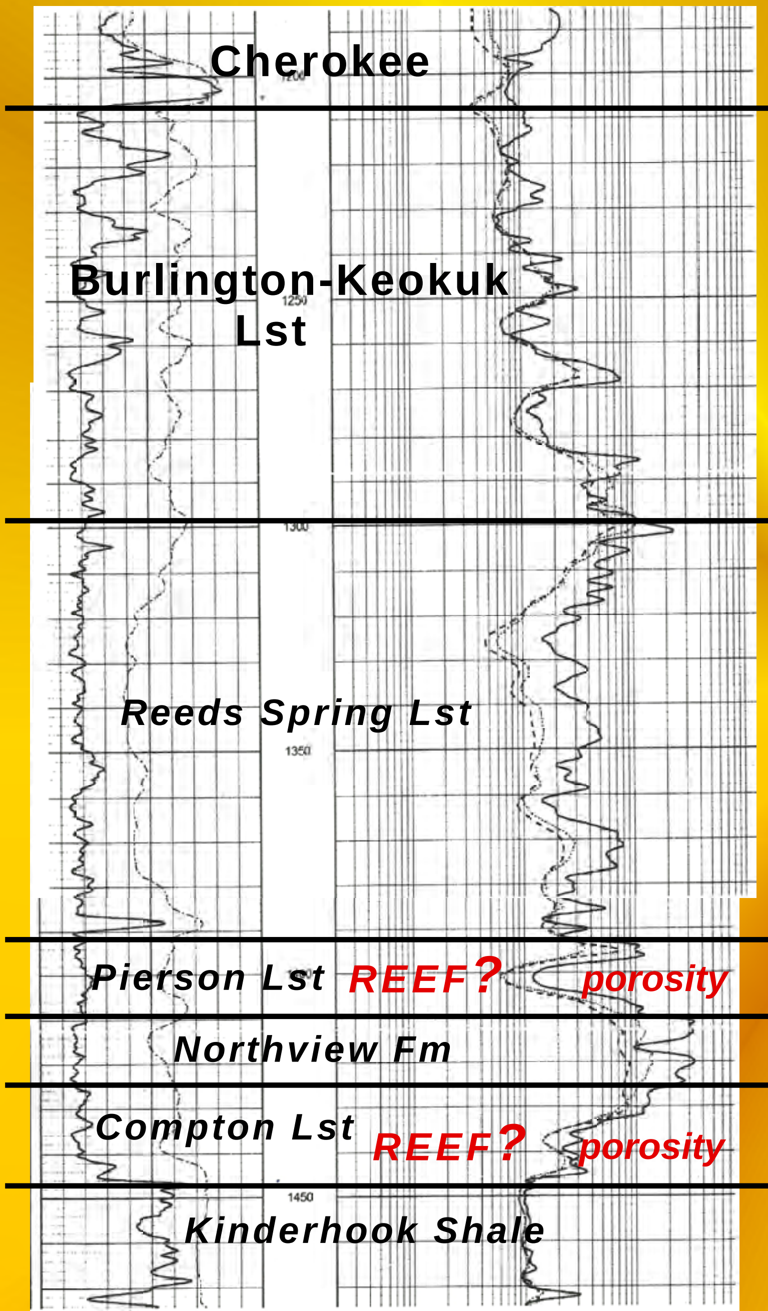
marine-cemented but with clear evidence of subaerial exposure and leaching/porosity formation

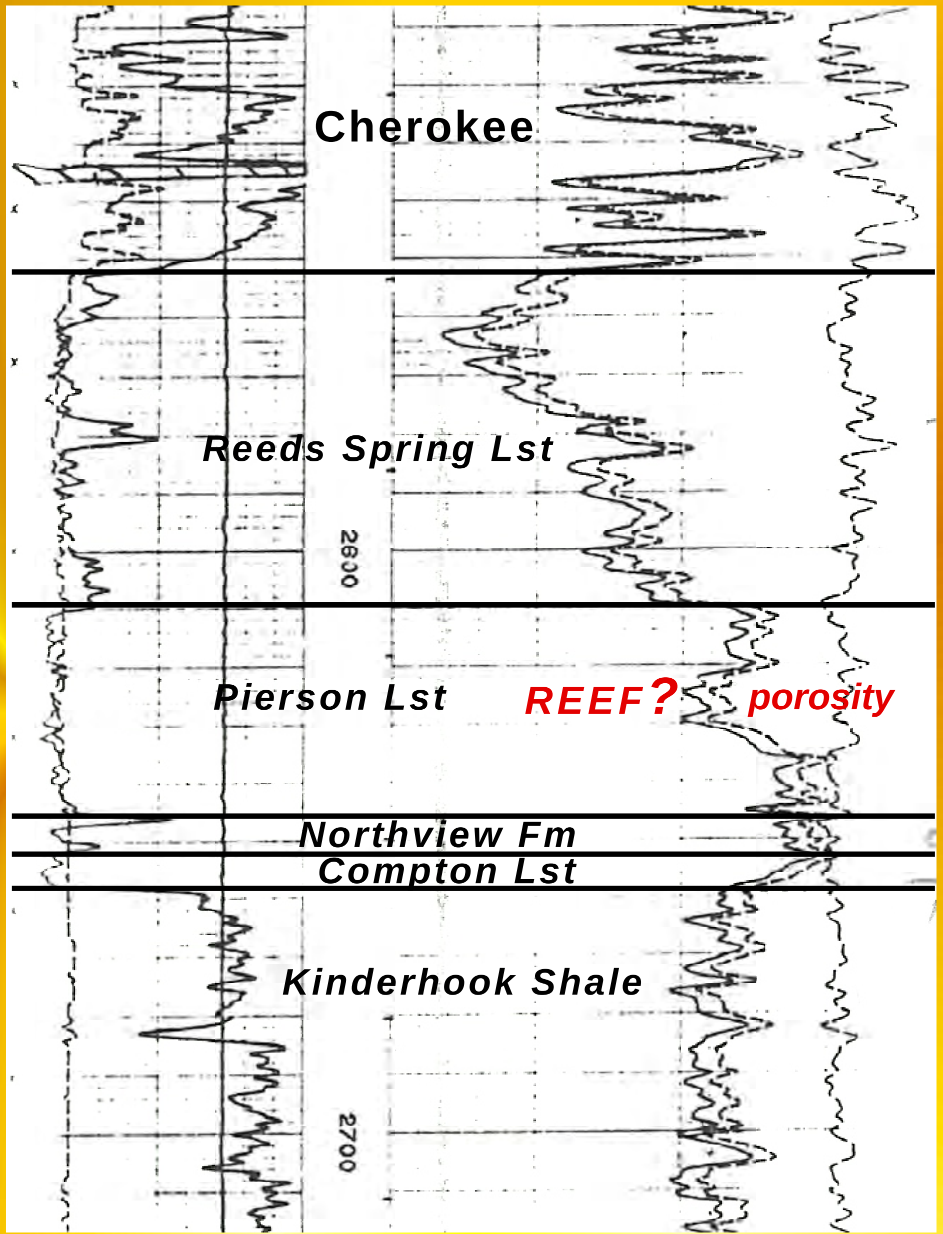
Pierson Reefs



also evidence of subaerial exposure and leaching/porosity formation...and oil-saturated on the outcrop

SUBSURFACE COMPTON & PIERSON REEFS?





WELL LOGS FROM NORTH OF THE KANOKA RIDGE, IN KANSAS, SHOWING POROSITY DEVELOPMENT IN THE COMPTON AND THE PIERSON -- PERHAPS REEFS?

LITHOSTRATIGRAPHIC REFLECTION OF SYNDEPOSITIONAL TECTONISM

- ***Northward dipping, resedimented limestones in the Compton, including reefs***

  PROBABLY NOT MAJOR EXPLORATION OBJECTIVES

- ***Northward dipping Pierson Fm carbonates (limestones and dolomites) that are erosionally truncated along the north side of the Kanoka Ridge***

  LIKELY EXPLORATION OBJECTIVE

- ***In-place reefs in the Compton and Pierson Formations (which locally are oil-stained or oil-saturated on the outcrop***

  LIKELY EXPLORATION OBJECTIVES

- ***Nearshore, shallow-marine carbonate and/or sandstone facies in the Northview Fm***

  LIKELY EXPLORATION OBJECTIVES?

NEARSHORE FACIES IN THE NORTHVIEW FM

Cherokee

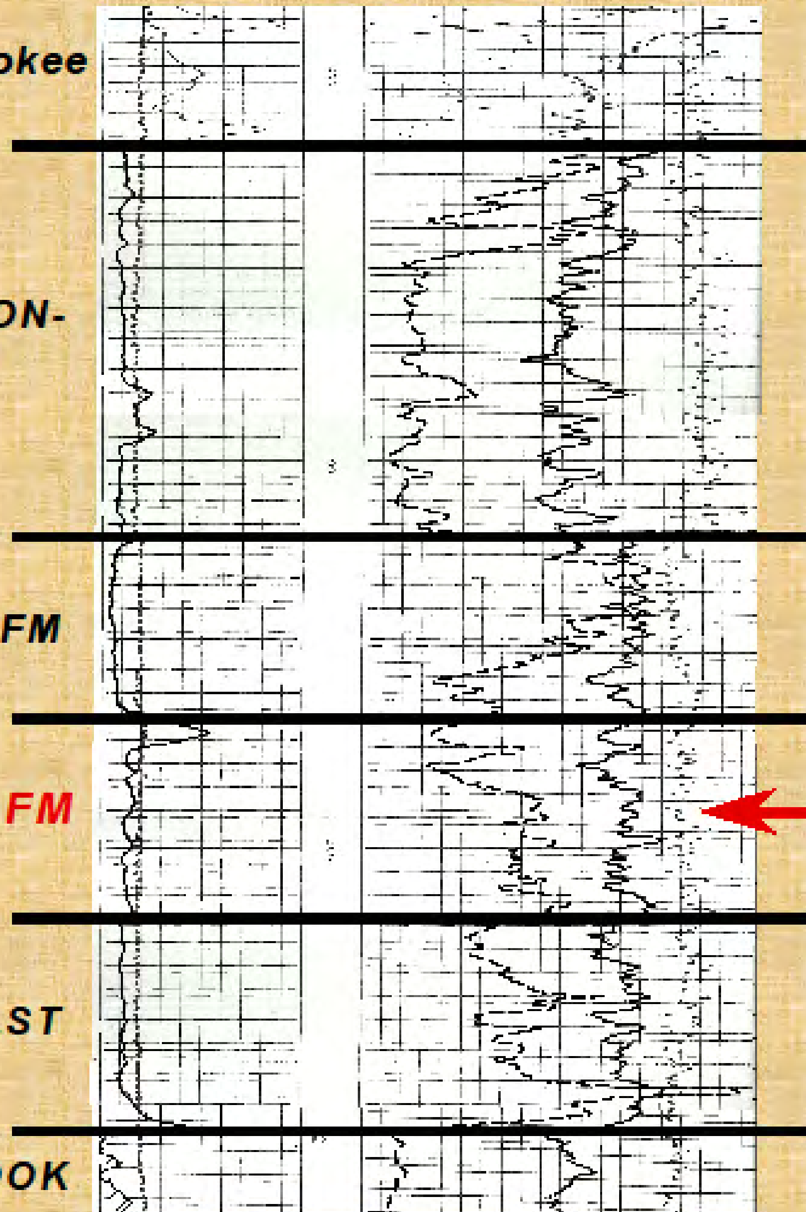
BURLINGTON-
KEOKUK

PIERSON FM

NORTHVIEW FM

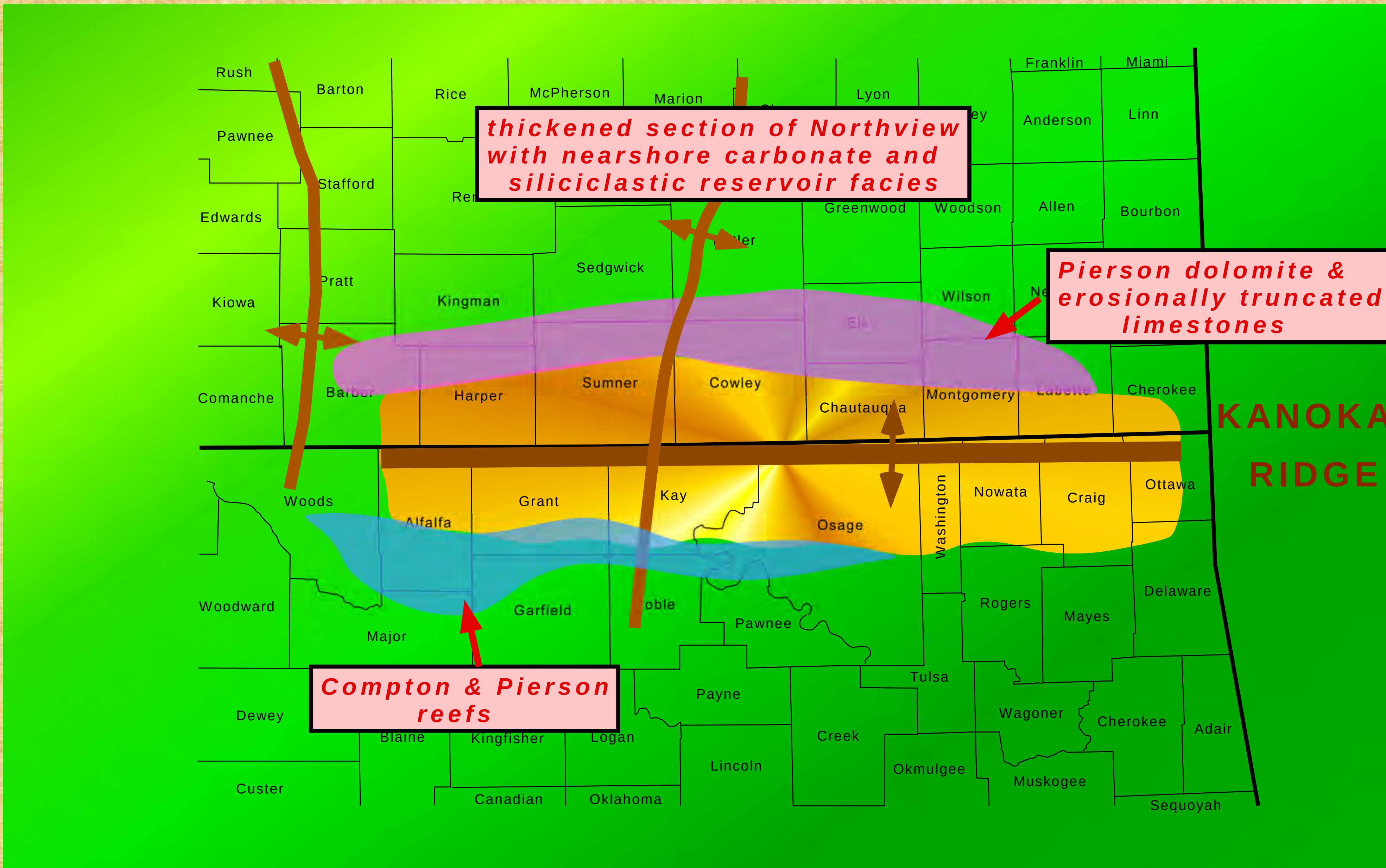
COMPTON LST

KINDERHOOK
SHALE

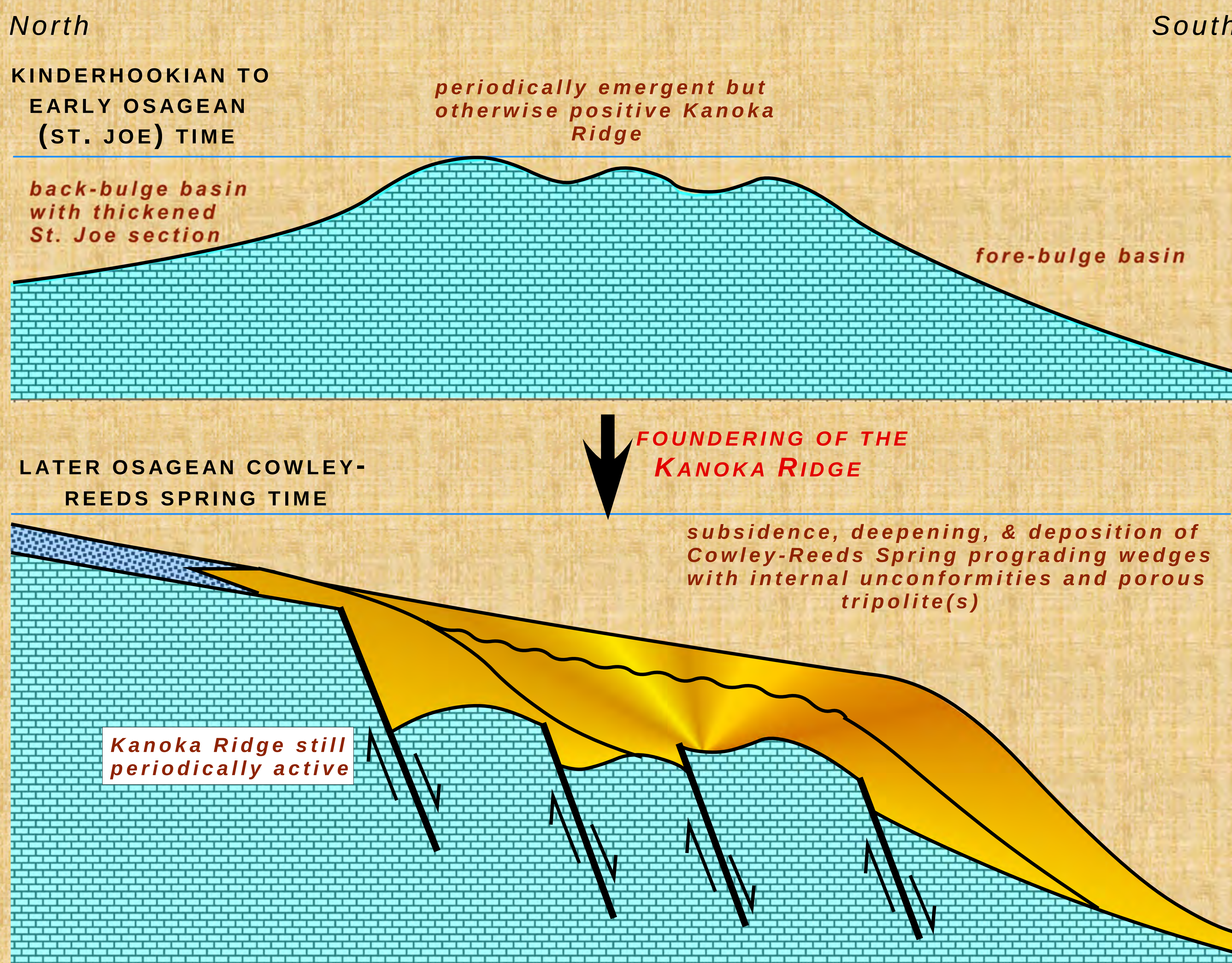


anomalously thick, porous, nearshore sandstones and carbonate sands (e.g., oolites)?

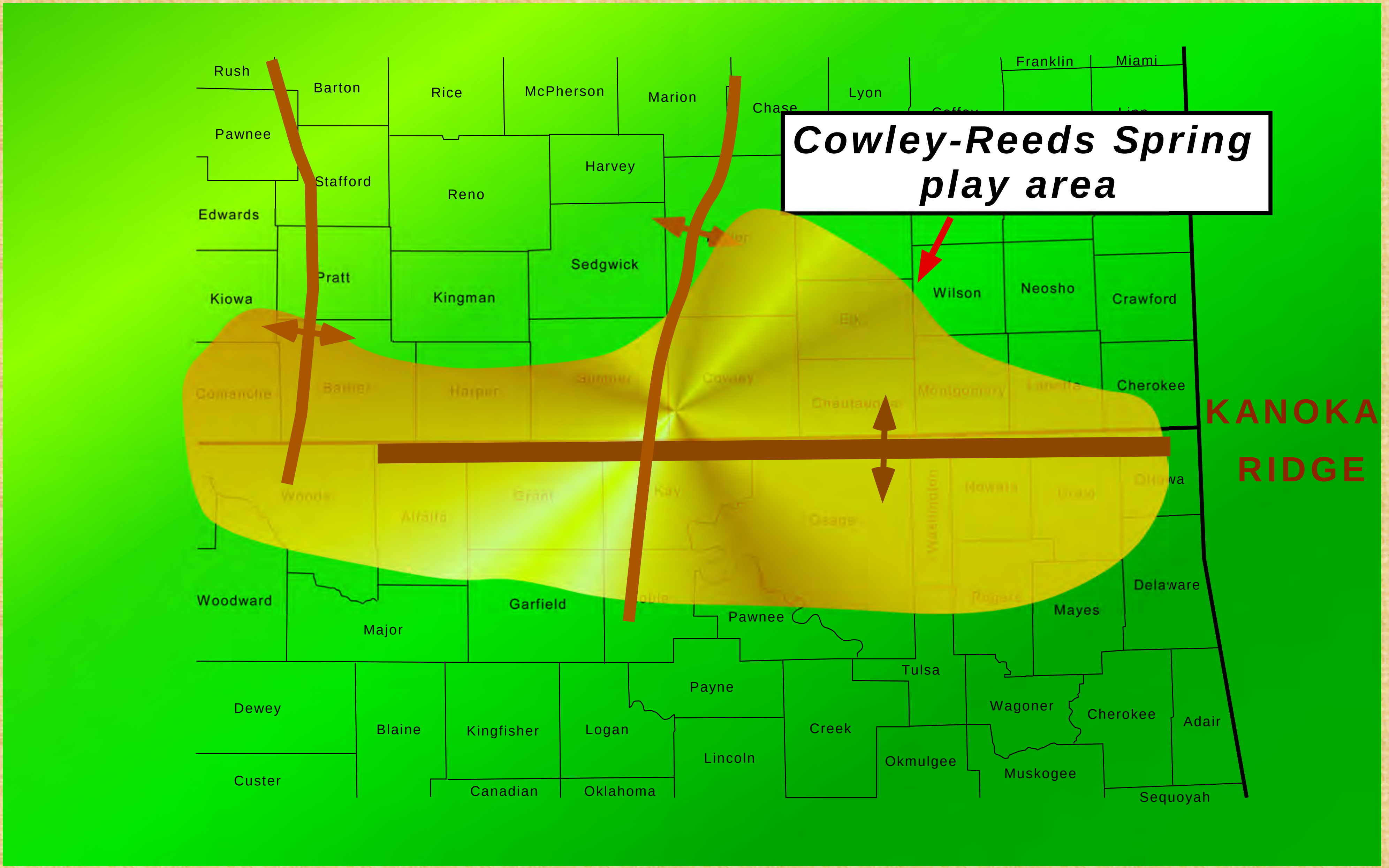
LOCATION OF ALL THESE POTENTIAL PLAYS



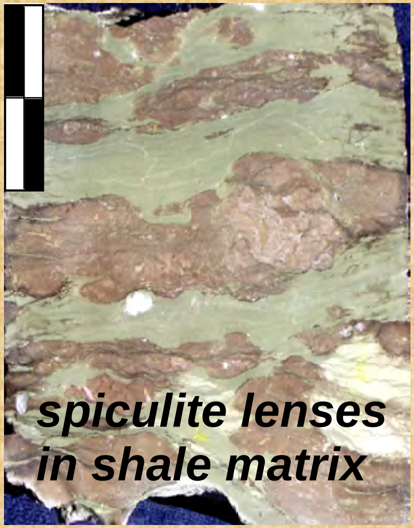
POST-ST. JOE TECTONIC AND DEPOSITIONAL HISTORY



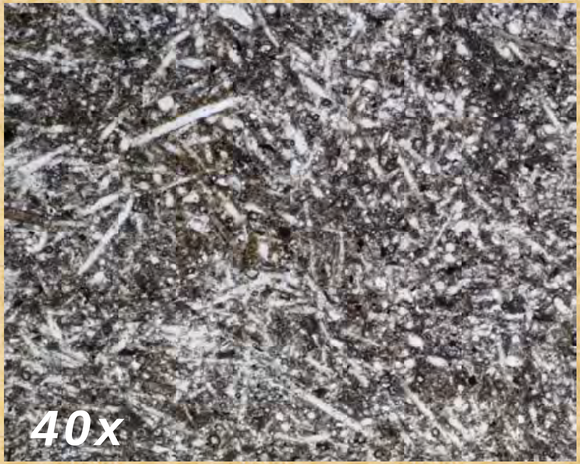
LOCATION OF COWLEY-REEDS SPRING PLAY

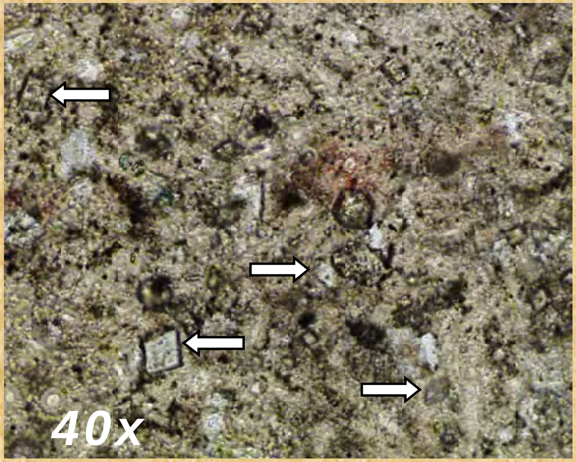


WHAT IS THE COWLEY?



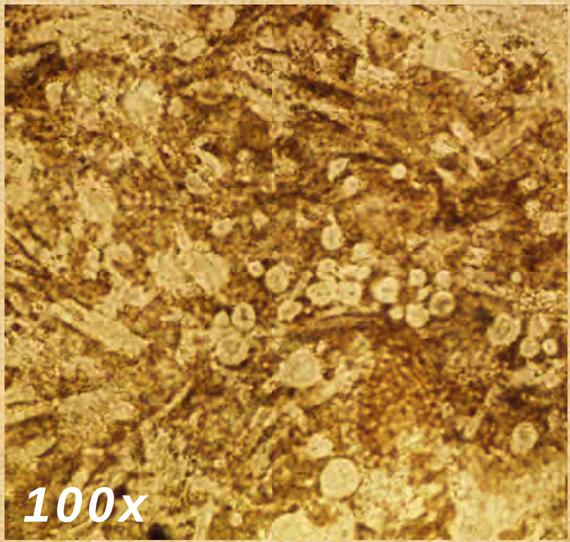
It is a lithologic unit comprising bedded spiculites and lenses of spicule in a shale or lime mud matrix





The spicules are 100-120 microns long, and they are very difficult (to impossible) to see with typical well-site microscopes. The rocks typically are slightly dolomitic

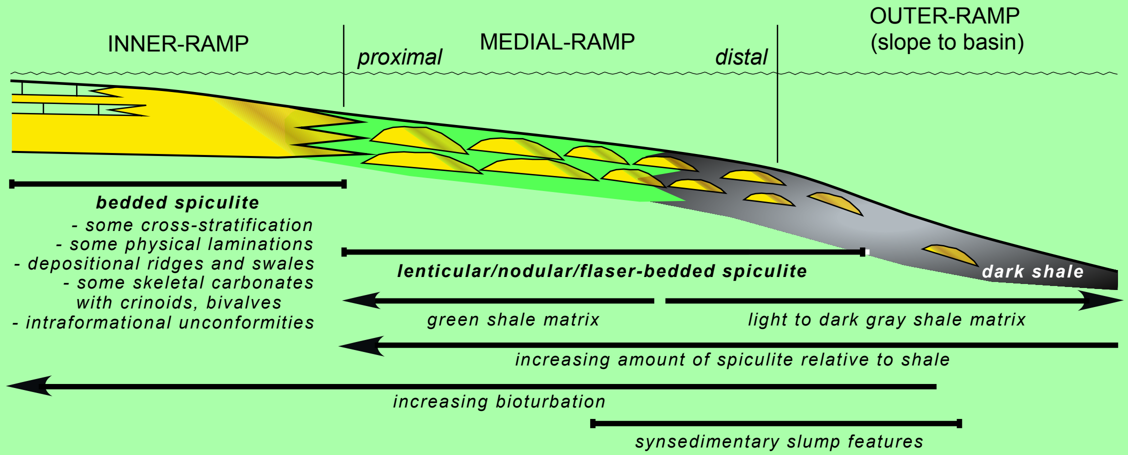
The component spicules are siliceous, hence the rocks are siliceous but only rarely are they cherty (just below unconformities



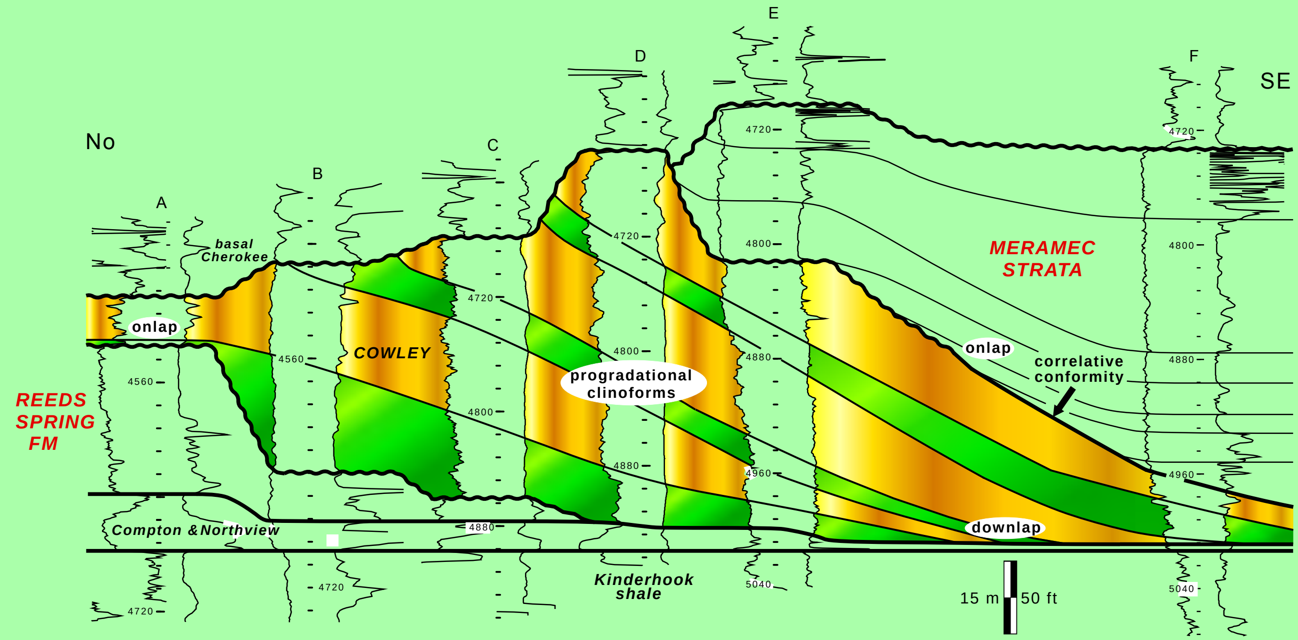
Cross-sectional views of the spicules are common, and give the appearance of being silt grains...

...and that is why the rocks are often referred to as "silty cherts", or "silty dolomites", or .....EVERYTHING BUT WHAT THEY ARE!

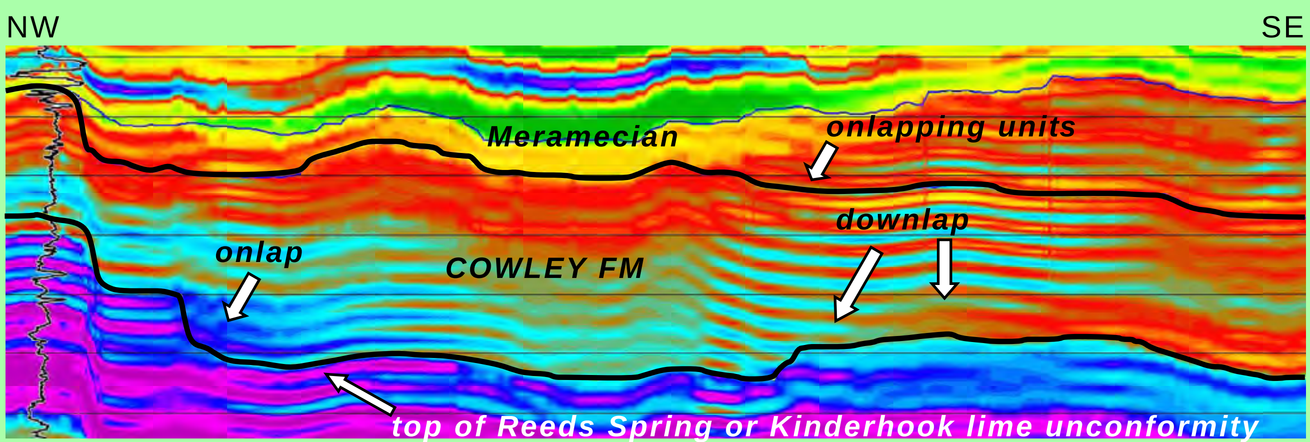
COWLEY ARCHITECTURE



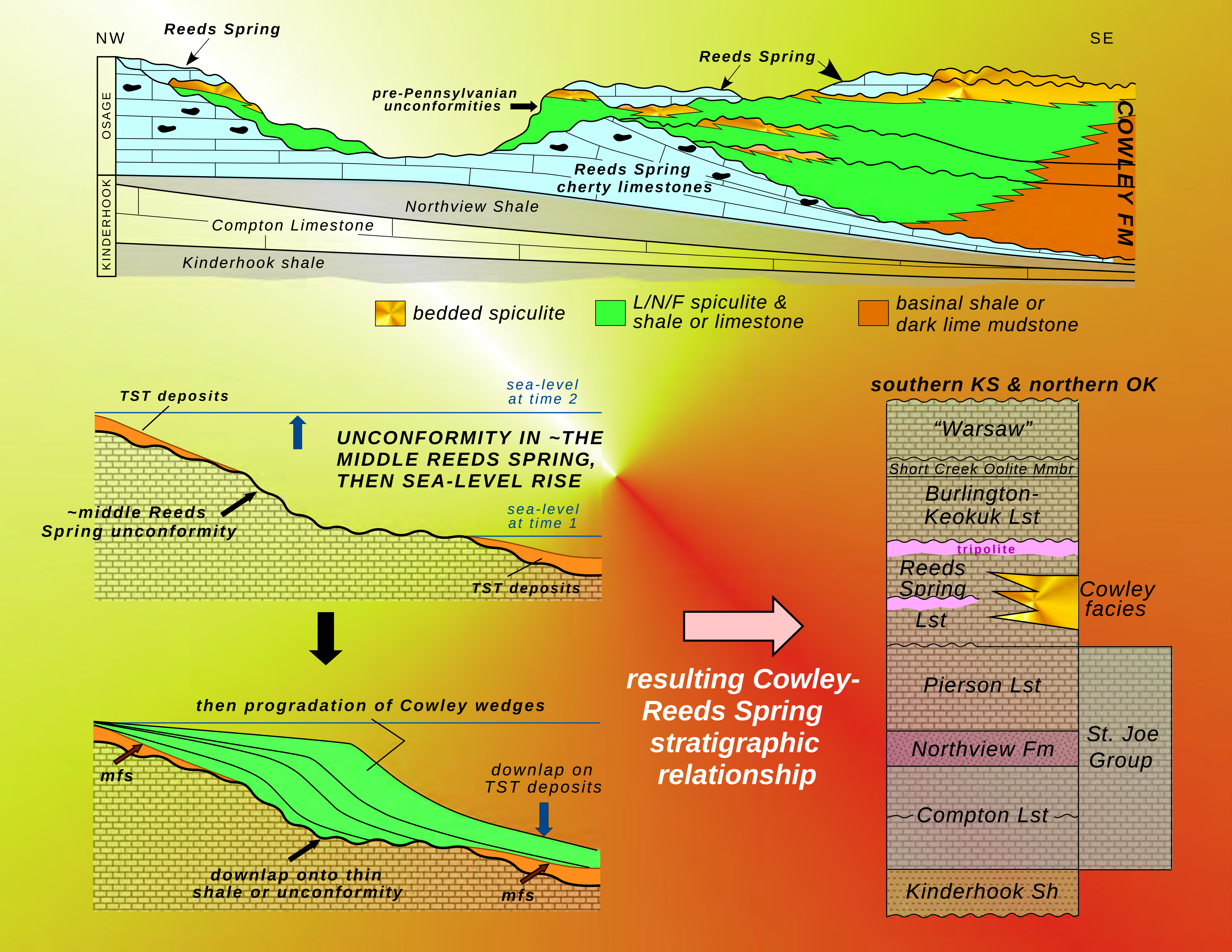
The Cowley was deposited on a low-angle ramp that graded seaward from relatively shallow to deeper-water environments



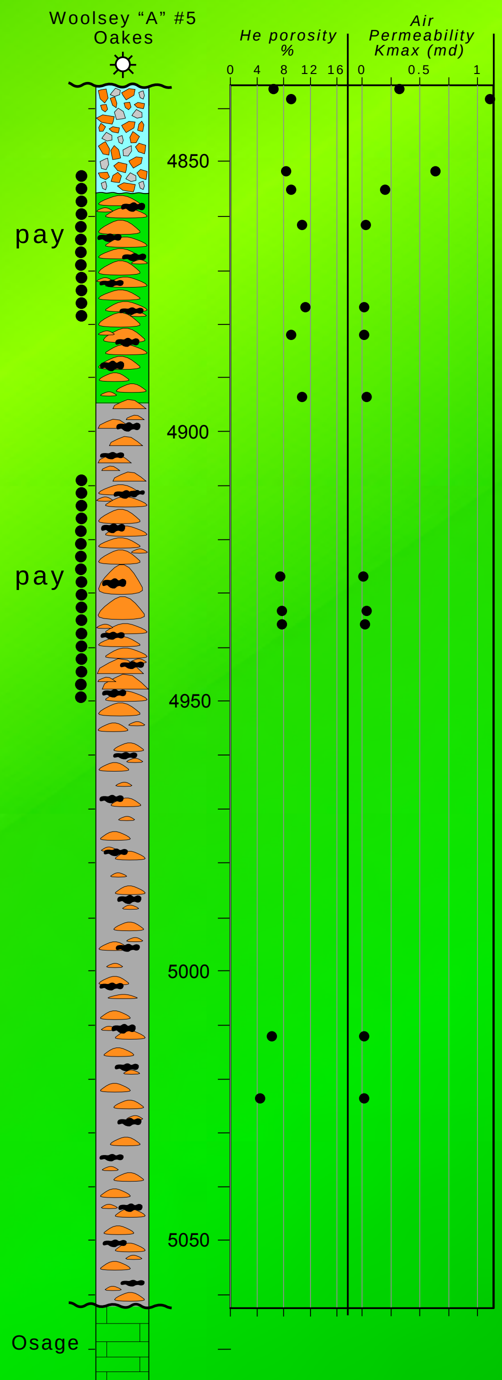
These facies prograded seaward as a series of separate, time-transgressive wedges

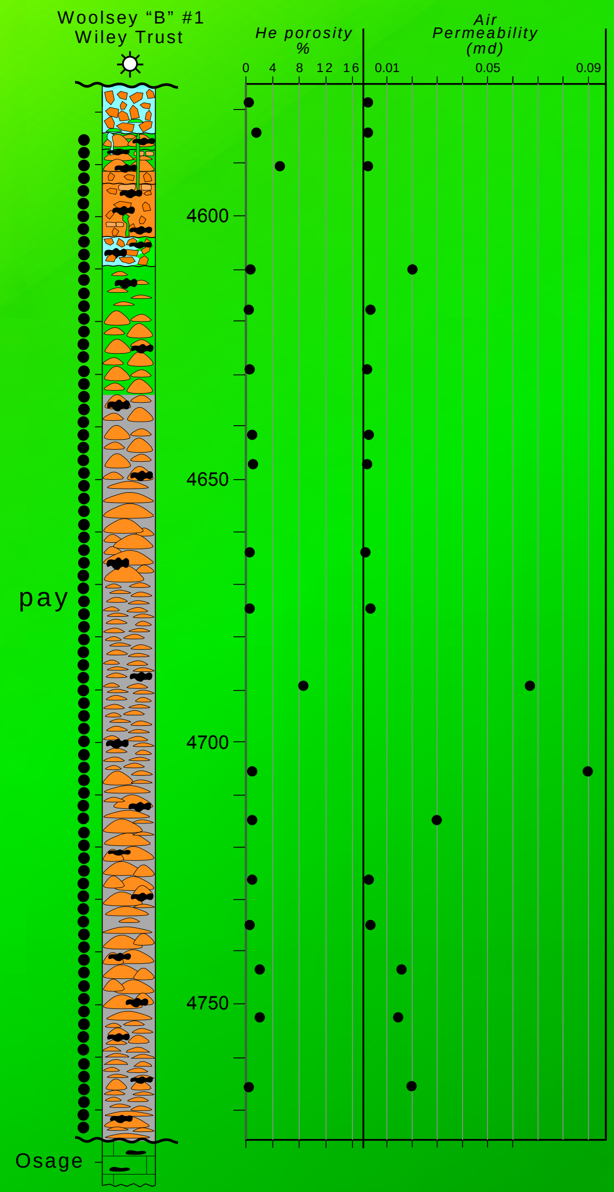


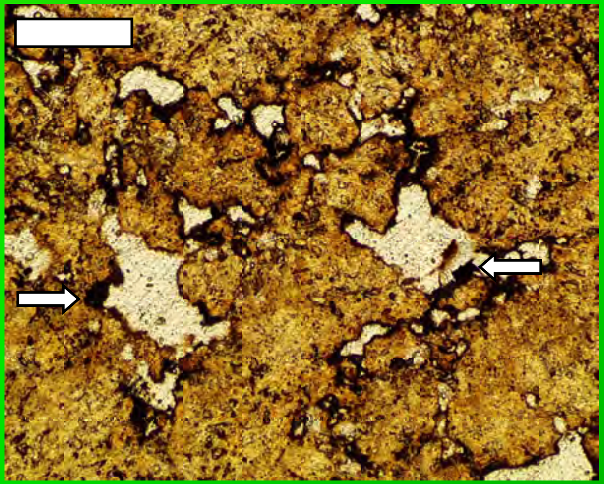
Such progradation is indicated on log cross-sections as well as on seismic lines!


NW
Reeds Spring
SE
Reeds Spring
pre-Pennsylvanian unconformities
OSAGE
KINDERHOOK
Reeds Spring cherty limestones
Northview Shale
Compton Limestone
Kinderhook shale
COWLEY FM
bedded spiculite
L/N/F spiculite & shale or limestone
basinal shale or dark lime mudstone
TST deposits
sea-level at time 2
UNCONFORMITY IN ~THE MIDDLE REEDS SPRING, THEN SEA-LEVEL RISE
~middle Reeds Spring unconformity
sea-level at time 1
TST deposits
then progradation of Cowley wedges
mfs
downlap on TST deposits
downlap onto thin shale or unconformity
mfs
resulting Cowley-Reeds Spring stratigraphic relationship
southern KS & northern OK
"Warsaw"
Short Creek Oolite Mmbr
Burlington-Keokuk Lst
tripolite
Reeds Spring Lst
Cowley facies
Pierson Lst
Northview Fm
St. Joe Group
Compton Lst
Kinderhook Sh

COWLEY PORE-PERM SYSTEMS



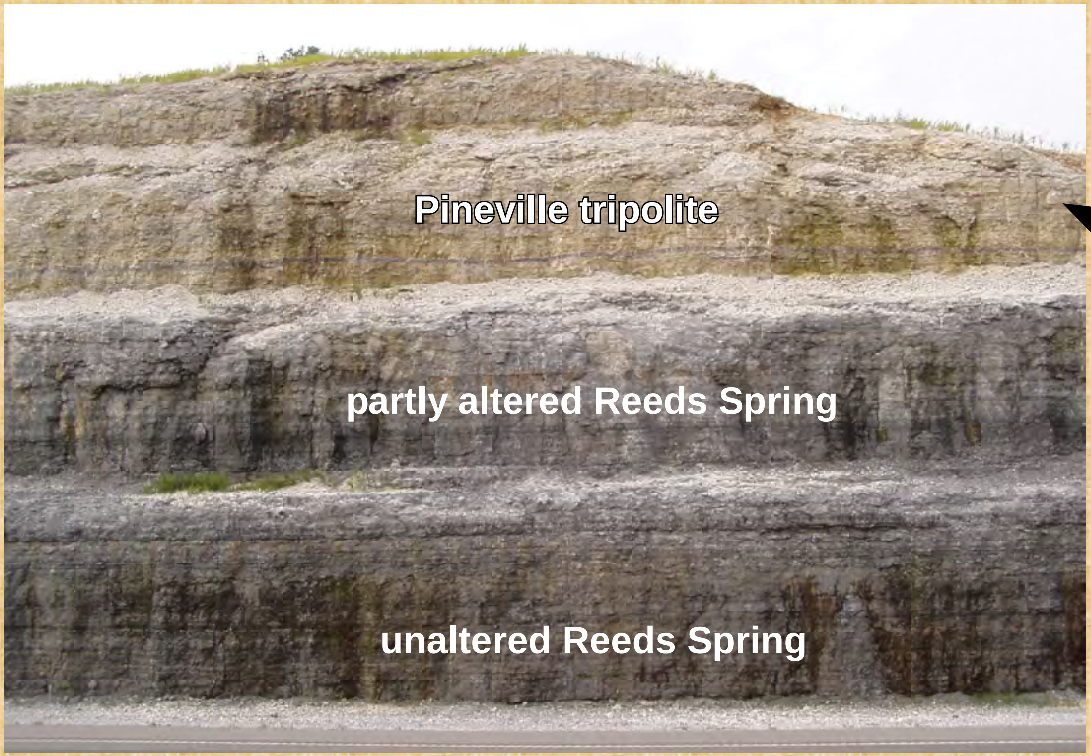




porosity in the Cowley is inter-spicule, intra-spicule, and vuggy

short and longer vertical fractures enhance the inherent low permeability of these rocks, within which thick sections of the Cowley can be perforated (depending on the amount of spiculite lenses)

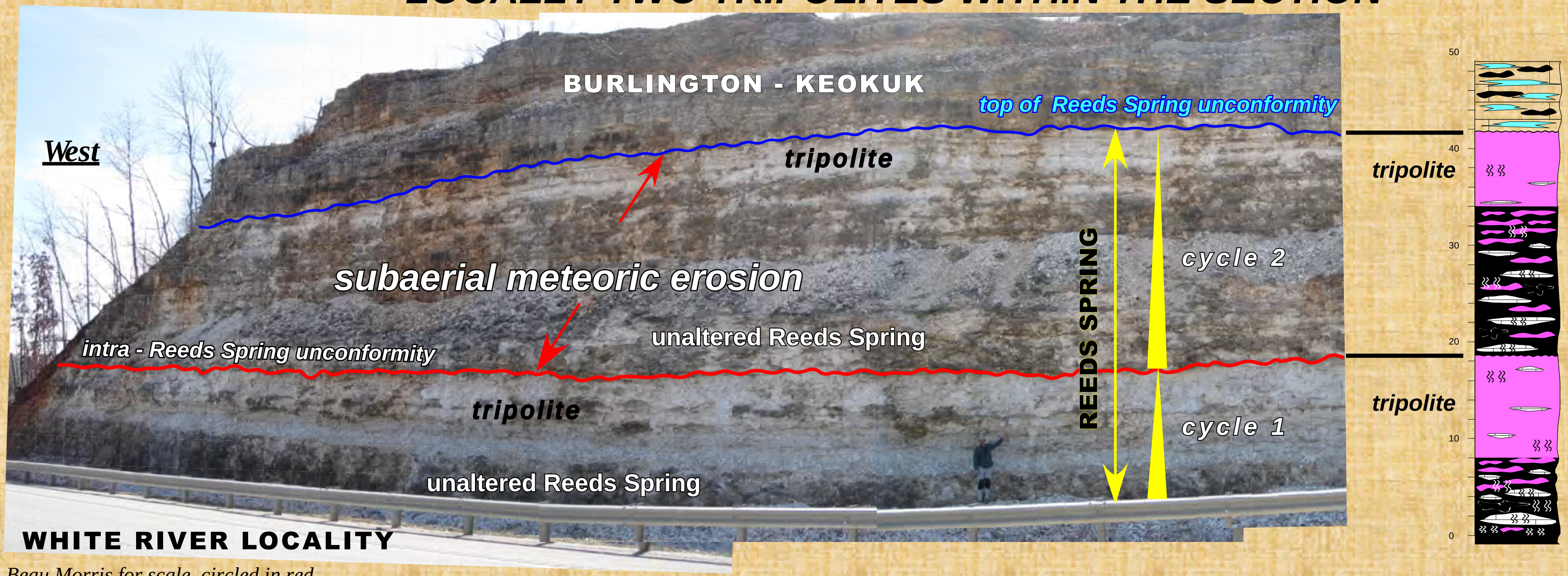
REEDS SPRING RESERVOIRS



tripolite at top of Reeds Spring:
RESERVOIR FACIES!!!

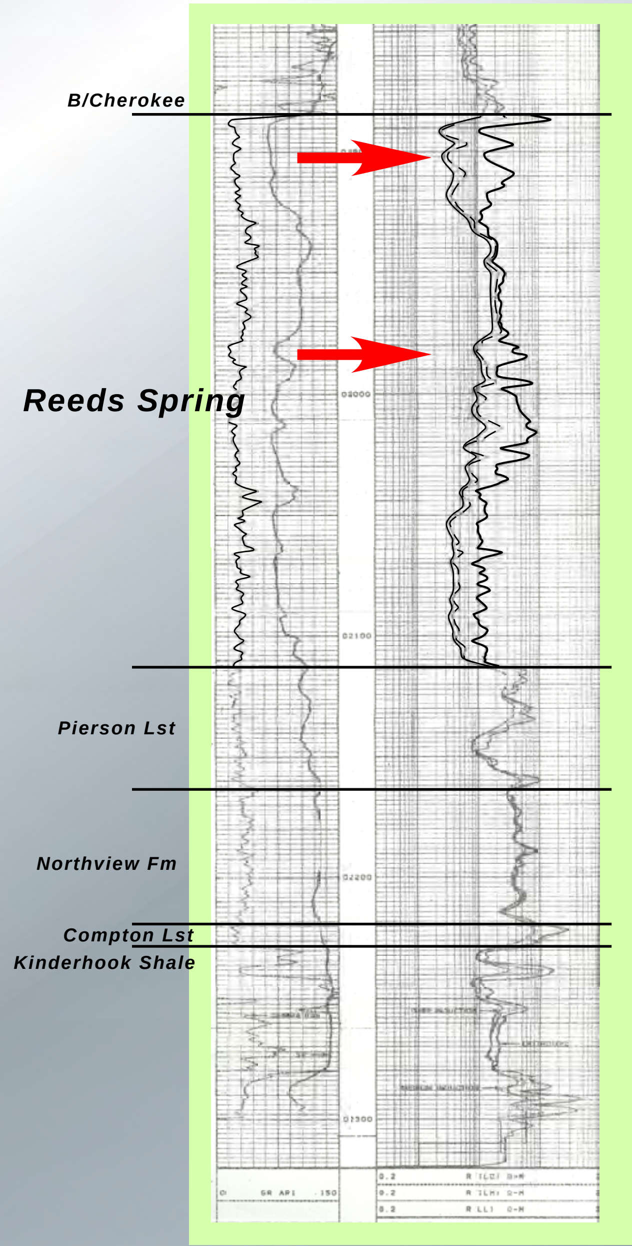
organic-rich, petroliferous chert and lime mudstone:
THE RESOURCE PLAY

LOCALLY TWO TRIPOLITES WITHIN THE SECTION



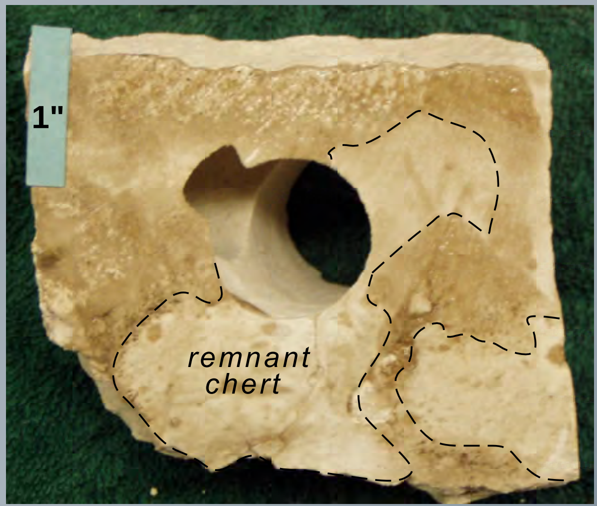
Beau Morris for scale, circled in red.

...and locally 2 tripolites in the subsurface (at least in southern Kansas)

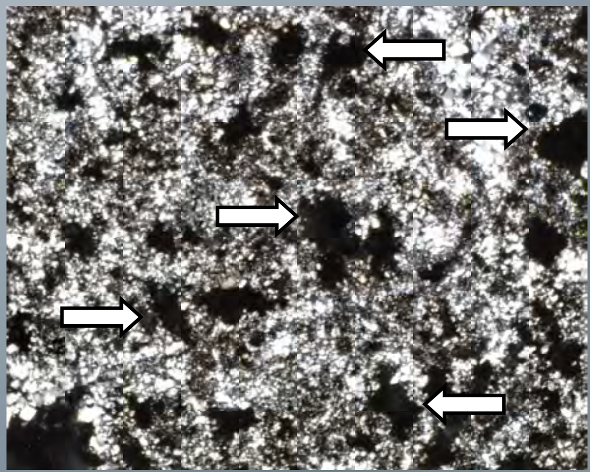


CORE SAMPLES OF TRIPOLITE

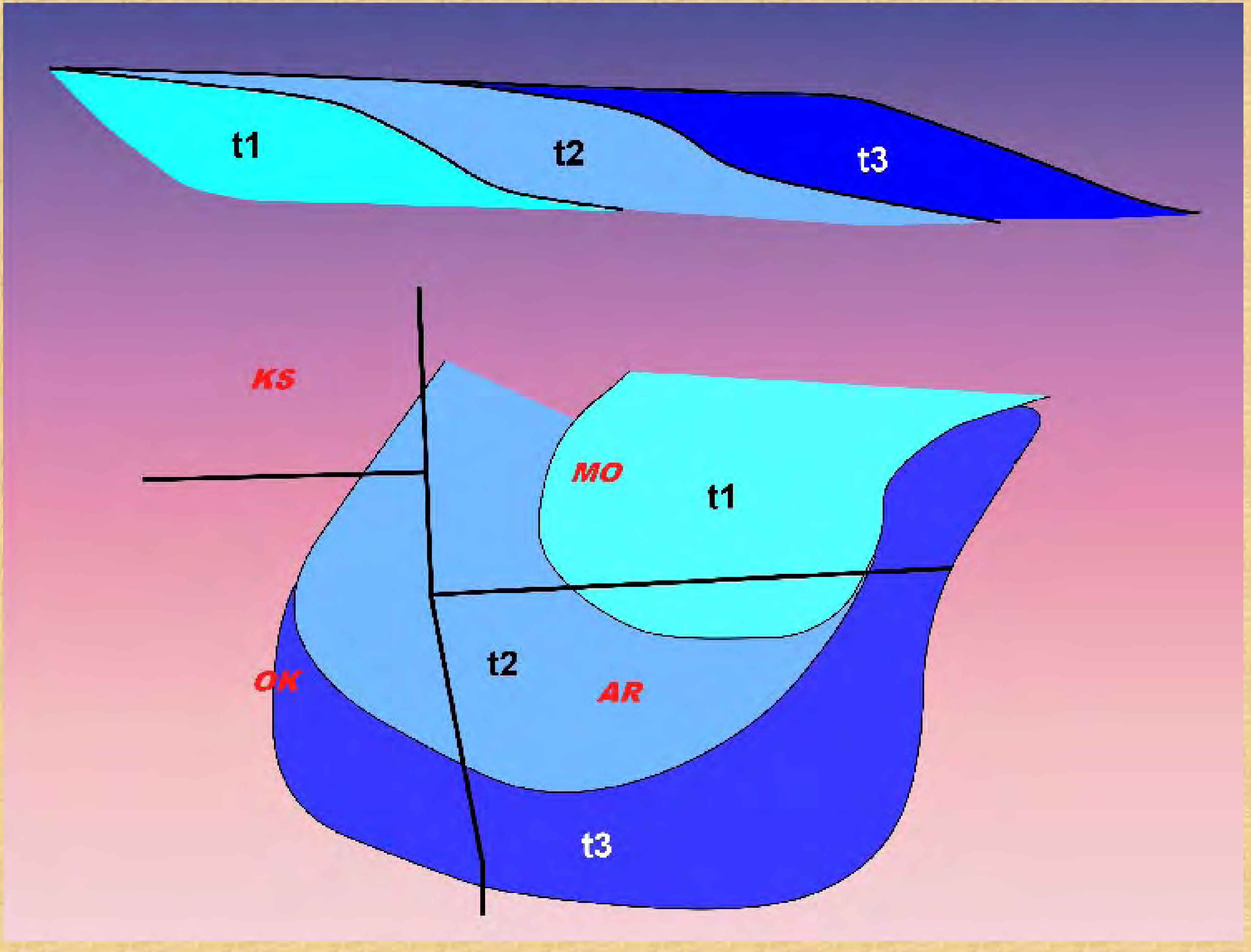
Tripolite with micro-interparticle pores, spiculite molds, and vugs (from Glick Field in Kiowa Co., KS)



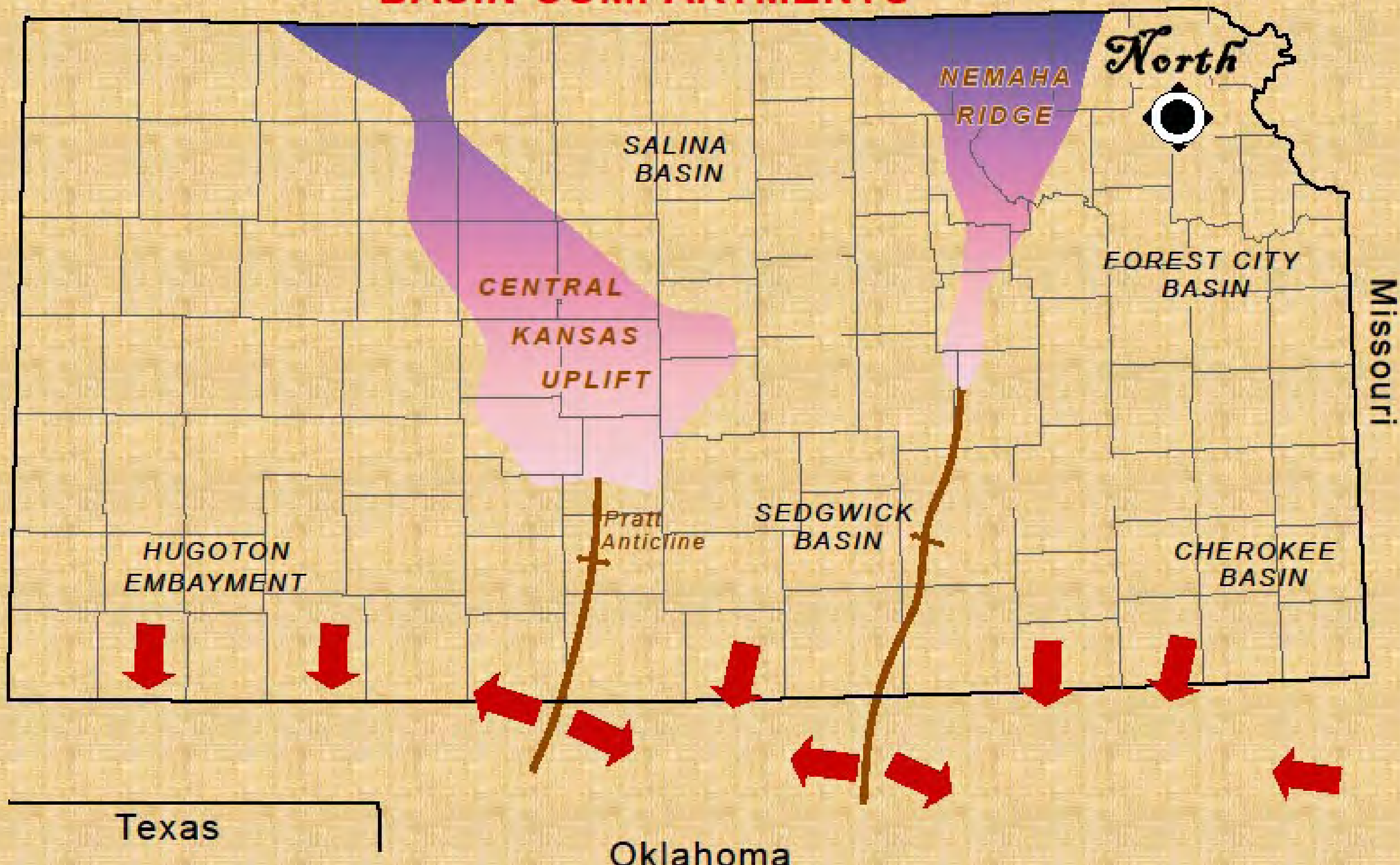
Micro-porous tripolite with remnant light colored, hard chert (Glick Field, Kiowa Co., KS)



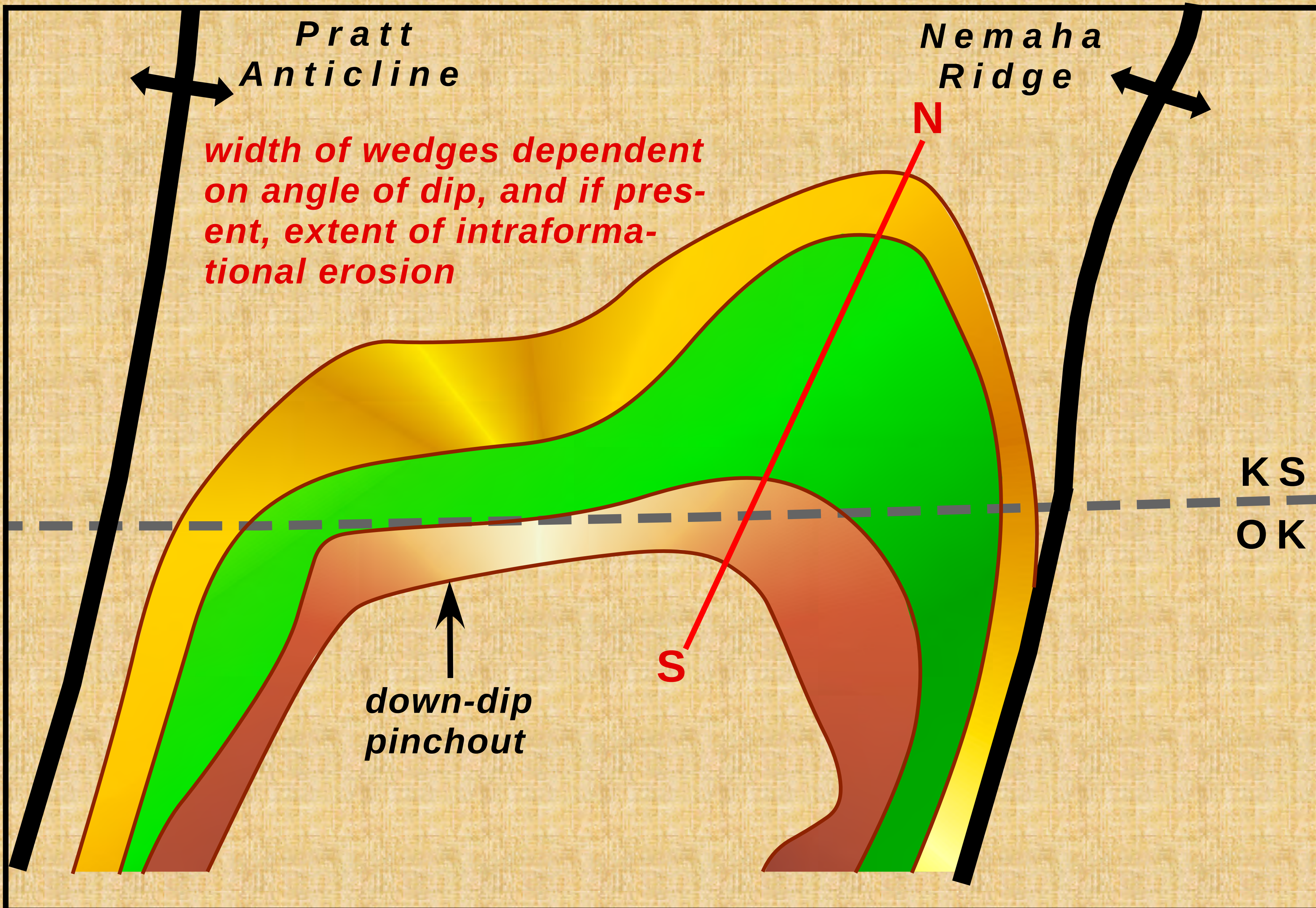
Thin-section photomicrograph (crossed nicols) of tripolites with abundant micro-pores (arrows). 40x magnification


t1
t2
t3
KS
MO
t1
OK
t2
AR
t3

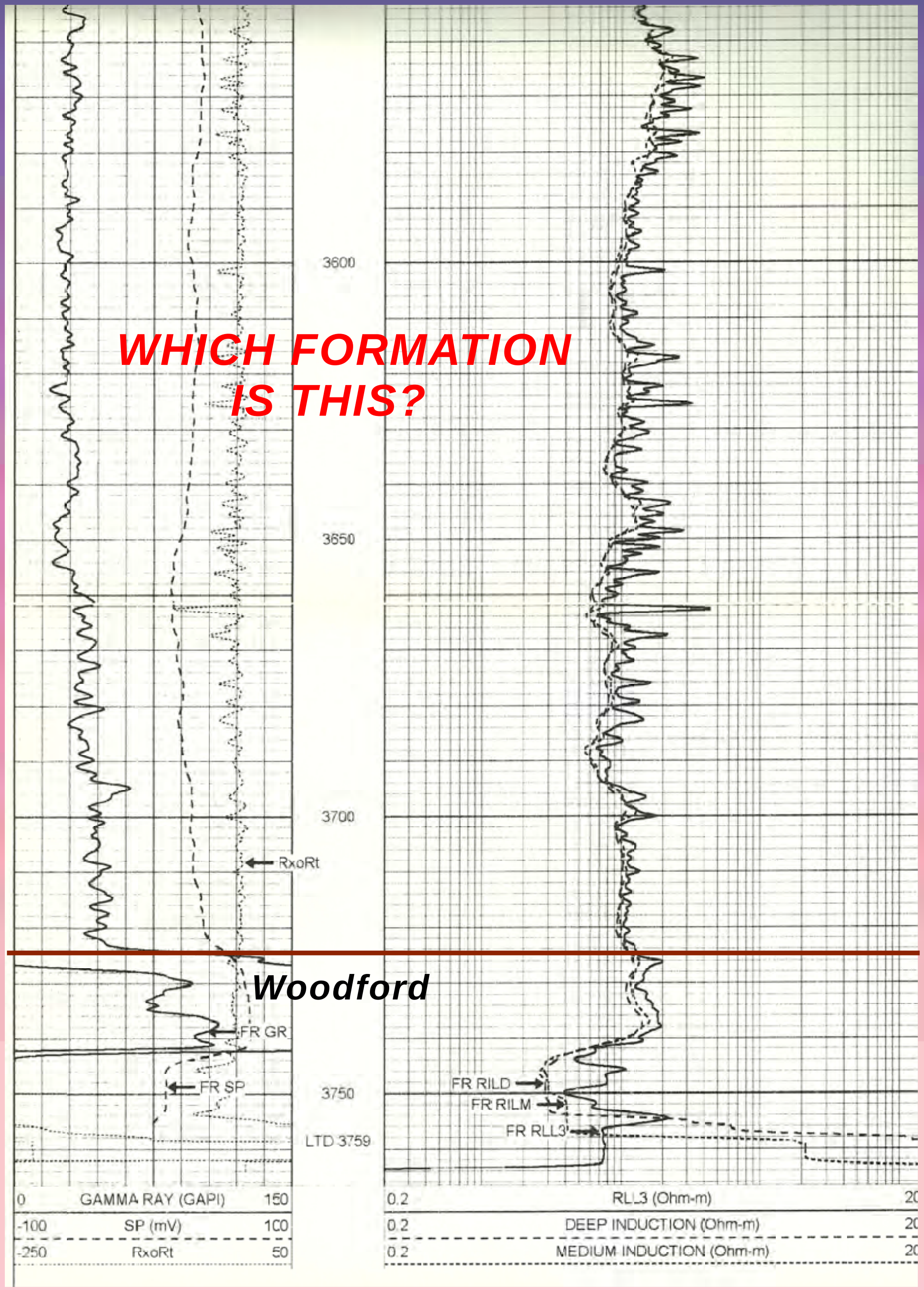
DIRECTIONS OF REEDS SPRING AND COWLEY PROGRADATIONAL WEDGES -- THAT DEFINE "BASIN COMPARTMENTS"



MAP VIEW OF INDIVIDUAL WEDGES (RESERVOIRS) IN THE REEDS SPRING OR COWLEY



THE NEED FOR SAMPLES



CONCLUSIONS

- ***There are several different play types, and areas of most potential play occurrence, in Mississippian strata depending on for which formation or formations one is exploring***
- ***Hence, one needs to identify which formation or formations is/are the reservoir objective(s)***
- ***Since formation identification cannot be done unequivocally based on logs, sample analysis is imperative (cores or cuttings)***
- ***Drill each Miss well into the Kinderhook Shale (if it's present) so that you have that stratigraphic marker for formation identification and correlation***
- ***Considering that the Miss is "all the same", or simply referring to the section as "chat" or "Miss lime" no longer suffices in the exploration effort***