New Insights into Lithostratigraphic Architecture of Subsurface Lower to Middle Mississippian Petroliferous Strata in Southern Kansas and Northern Oklahoma*

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Abstract

Lithostratigraphic and architectural development of Lower-Middle Mississippian rocks in southern Kansas and northern Oklahoma and petroleum reservoirs therein were affected by syndepositional tectonism related to Ouachita plate convergence. Tectonism during the Kinderhookian to early Osagean resulted in southward shallowing, erosional thinning, and on-lap of the St. Joe Group onto the Kanoka Ridge, which precluded distal deepening into starved, condensed basinal shales. Foundering of the ridge in middle Osagean time coincided with increased subsidence and northward back stepping of deeper-water environments on the Burlington Shelf, and then rapid southward progradation of the Reeds Spring-Bentonville slope and platform depositional system. Progradation likely was facilitated by limited subsidence and accommodation space during this time and rapid influx of platform-derived sediments. Uplift along the Kanoka Ridge during the late Osagean resulted in tripolite formation in the upper Reeds Spring Limestone, and then erosion of a paleotopographic low into which the Cowley Formation was deposited. Progradational, spiculitic Cowley facies in the north are shale-dominated and younger wedges in Oklahoma are carbonate-dominated. Chert-clast breccia in the Bentonville, tripolite in the Reeds Spring, and spiculite in the Cowley are the main petroleum reservoirs in these rocks, and porosity in each is of secondary meteoric-dissolutional origin.

Reference Cited

Boardman, D.R., T.L. Thompson, C. Godwin, S.J. Mazzullo, B.W. Wilhite, and B.T. Morris, 2013, High-resolution conodont zonation for Kinderhookian (middle Tournaisian) and Osagean (upper Tournaisian-lower Visean) strata of the western edge of the Ozark Plateau, North America: Shale Shaker, v. 64, p. 98-151.

NEW INSIGHTS INTO LITHOSTRATIGRAPHIC ARCHITECTURE OF SUBSURFACE LOWER TO MIDDLE MISSISSIPPIAN PETROLIFEROUS STRATA IN SOUTHERN KANSAS AND AND NORTHERN OKLAHOMA

S. J. Mazzullo[1] & Brian W. Wilhite

from the outcrop into the subsurface

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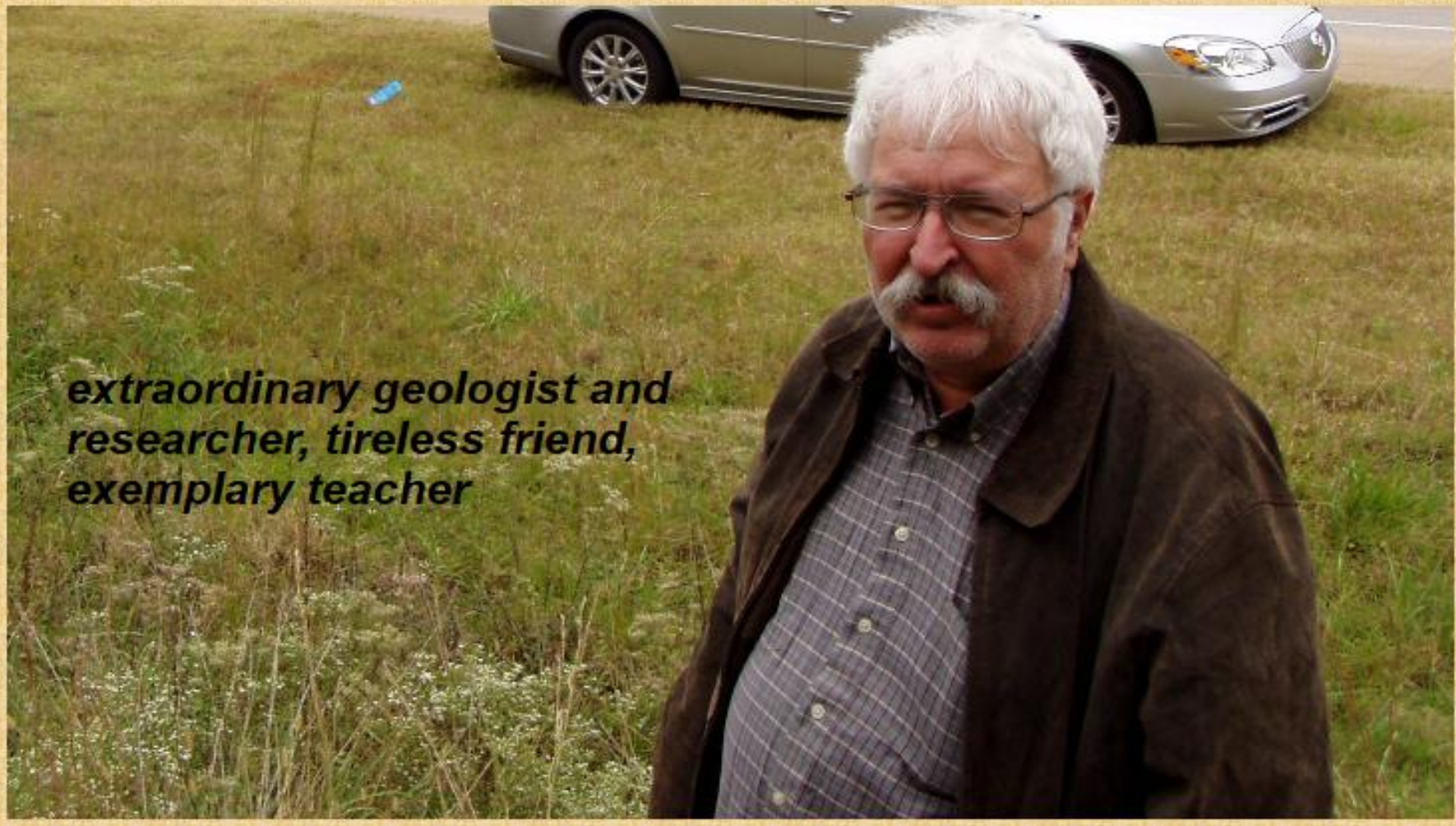
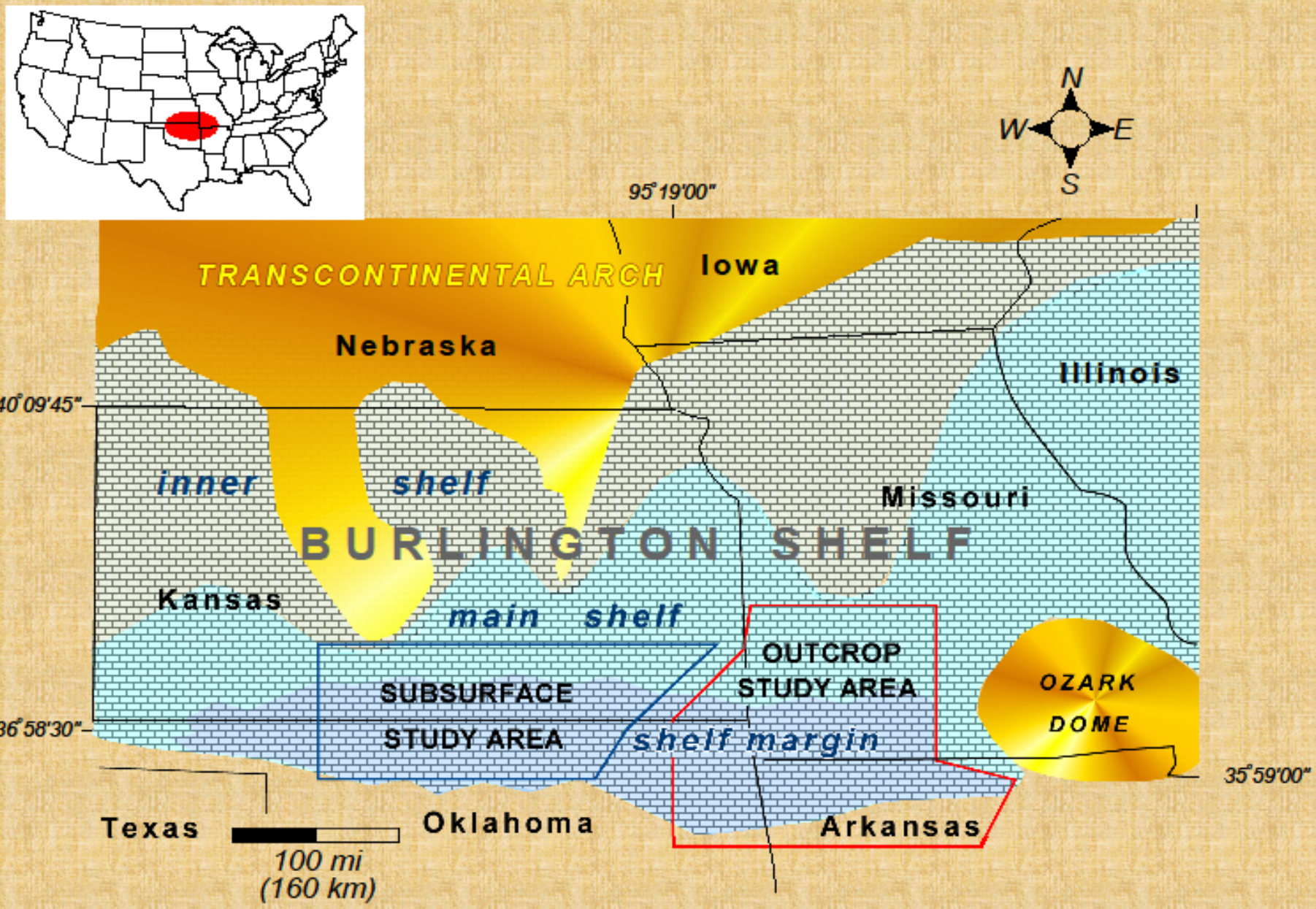
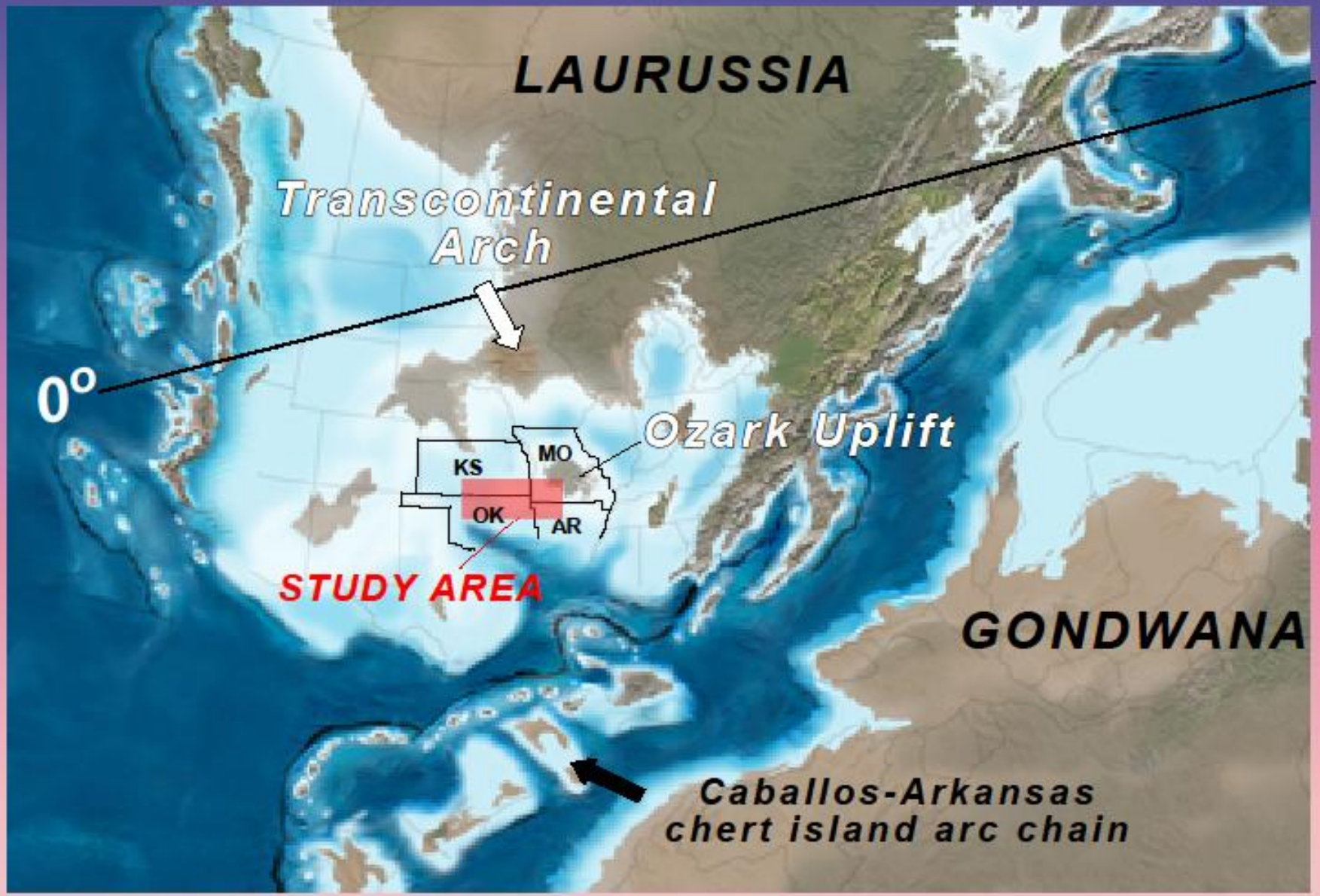
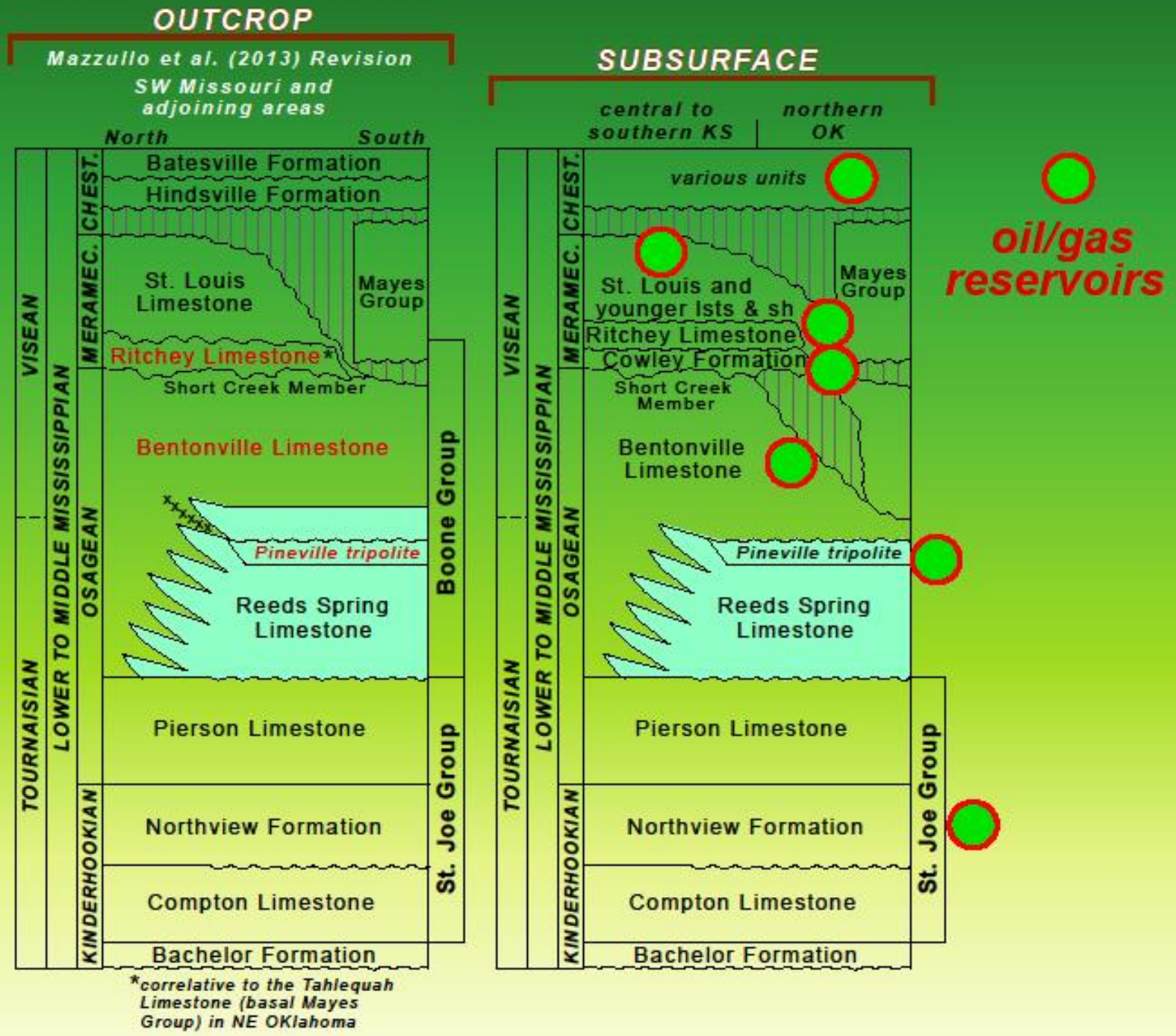
IN MEMORY OF OUR FRIEND
AND ESTEEMED COLLEAGUE,
DR. DARWIN R. BOARDMAN, II
1951-2015



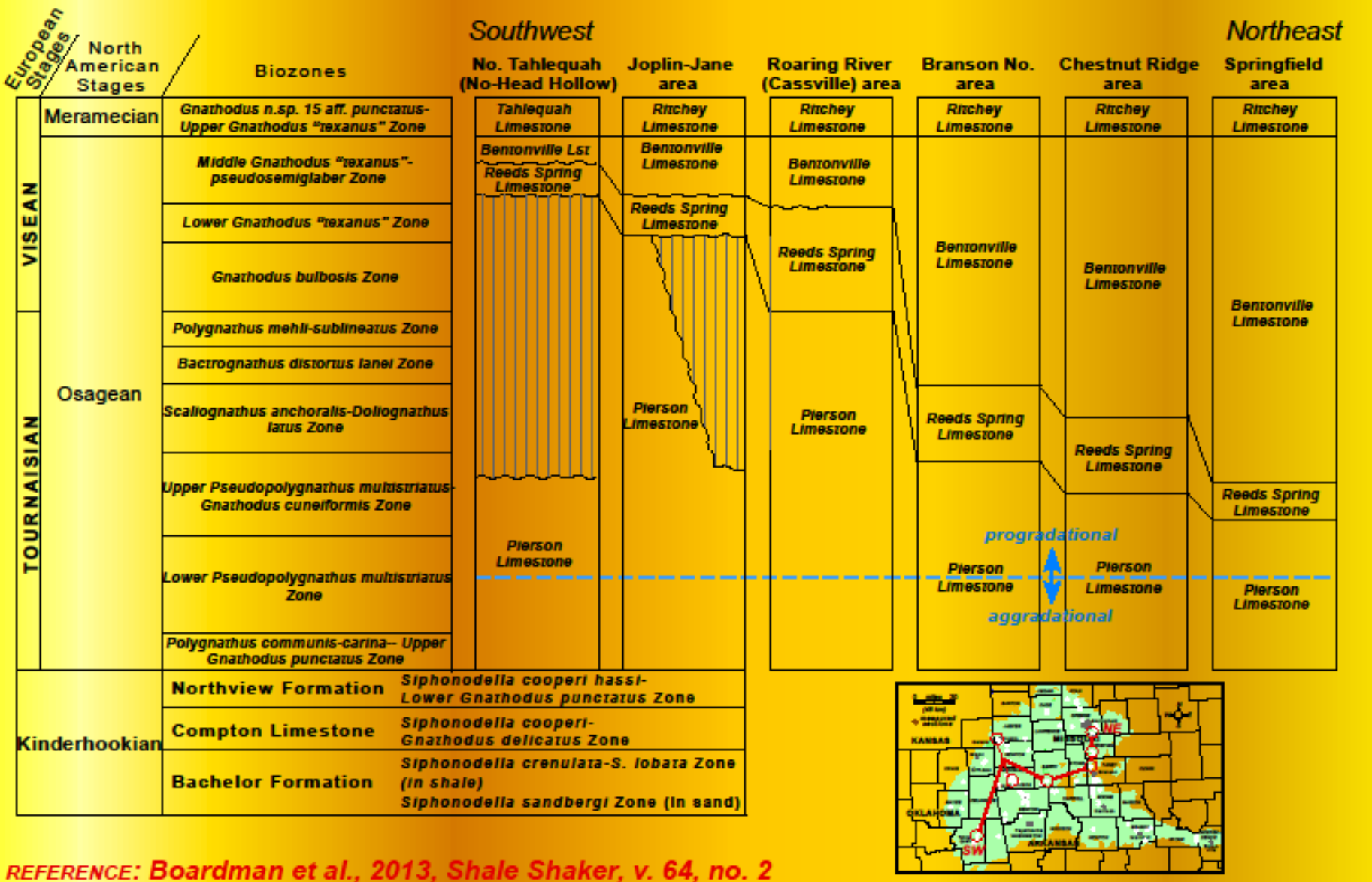

N
W
E
S
95°19'00"
TRANSCONTINENTAL ARCH
Iowa
Nebraska
Illinois
40°09'45"
inner shelf
Missouri
BURLINGTON SHELF
Kansas
main shelf
OUTCROP
STUDY AREA
SUBSURFACE
STUDY AREA
OZARK
DOME
36°58'30"
shelf margin
35°59'00"
Texas
Oklahoma
Arkansas
100 mi
(160 km)



SOUTHERN MIDCONTINENT WAS AFFECTED BY EPISODIC SYNDEPOSITIONAL COMPRESSIONAL (~N-S) TECTONISM DURING THE MISSISSIPPIAN TO EARLY PENNSYLVANIAN, AND TECTONO-EUSTATIC FLUCTUATIONS

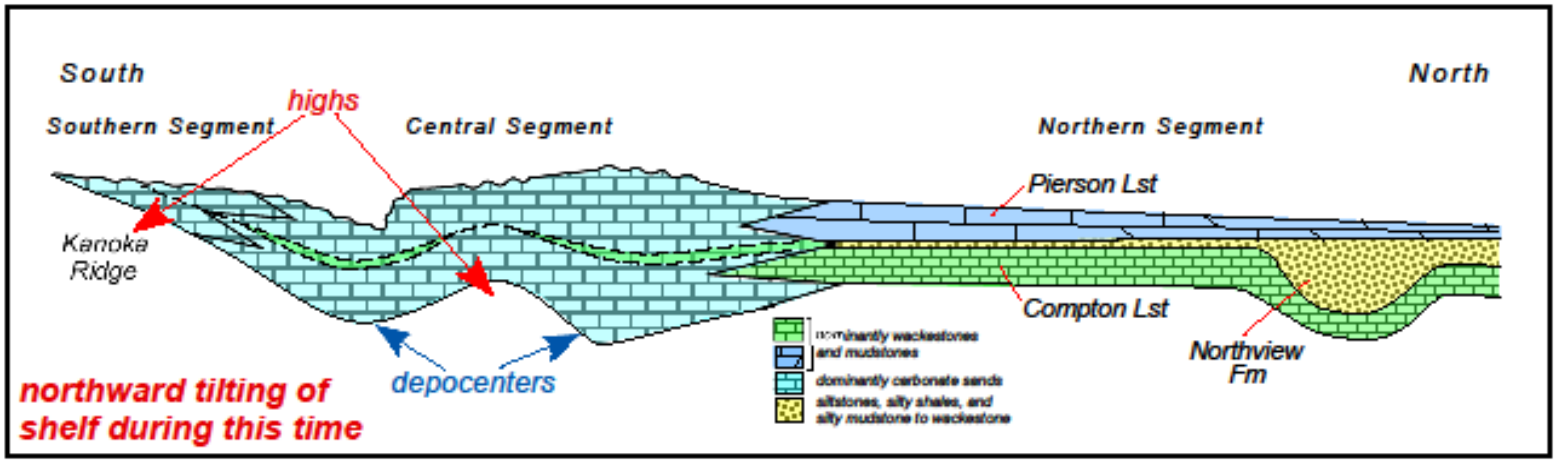

OUTCROP
Mazzullo et al. (2013) Revision
SW Missouri and adjoining areas
North
South
VISEAN
TOURNAISIAN
LOWER TO MIDDLE MISSISSIPPIAN
CHEST.
MERAMEC.
OSAGEAN
KINDERHOOKIAN
Batesville Formation
Hindsville Formation
St. Louis Limestone
Mayes Group
Ritchey Limestone*
Short Creek Member
Bentonville Limestone
Pineville tripolite
Reeds Spring Limestone
Pierson Limestone
Northview Formation
Compton Limestone
Bachelor Formation
Boone Group
St. Joe Group
*correlative to the Tahlequah Limestone (basal Mayes Group) in NE OKlahoma
SUBSURFACE
central to southern KS
northern OK
various units
St. Louis and younger lsts & sh
Ritchey Limestone
Cowley Formation
Short Creek Member
Bentonville Limestone
Pineville tripolite
Reeds Spring Limestone
Pierson Limestone
Northview Formation
Compton Limestone
Bachelor Formation
Mayes Group
St. Joe Group
oil/gas reservoirs

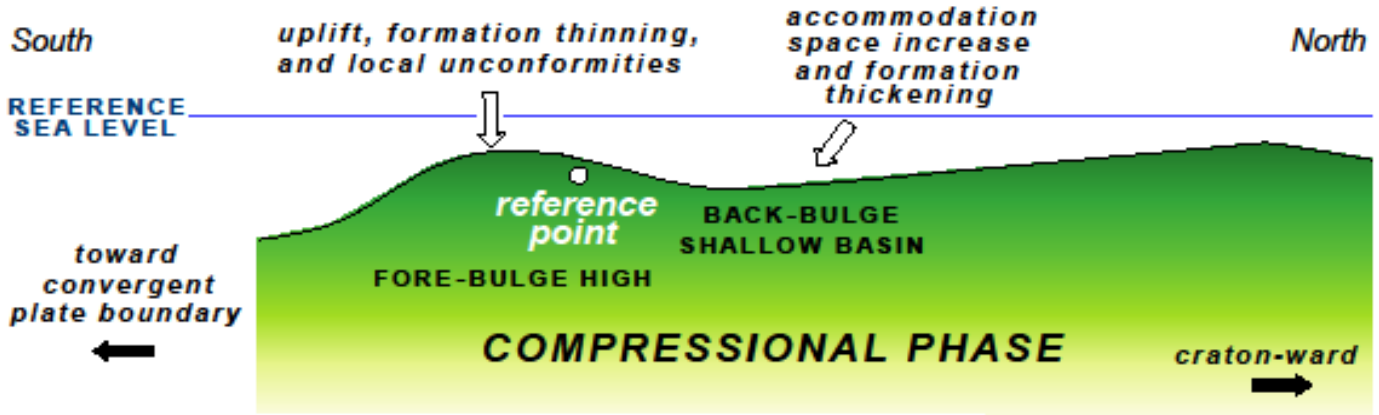
CONODONT BIOSTRATIGRAPHY

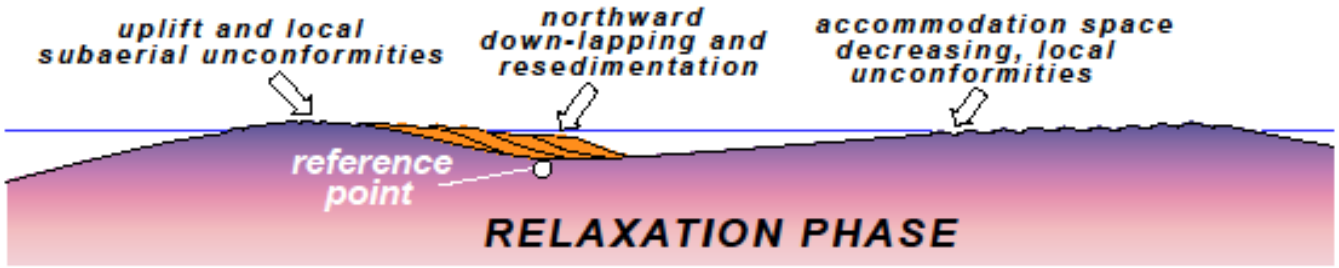


REFERENCE: Boardman et al., 2013, Shale Shaker, v. 64, no. 2

OUTCROP LITHOSTRATIGRAPHIC ARCHITECTURE, ST. JOE GROUP

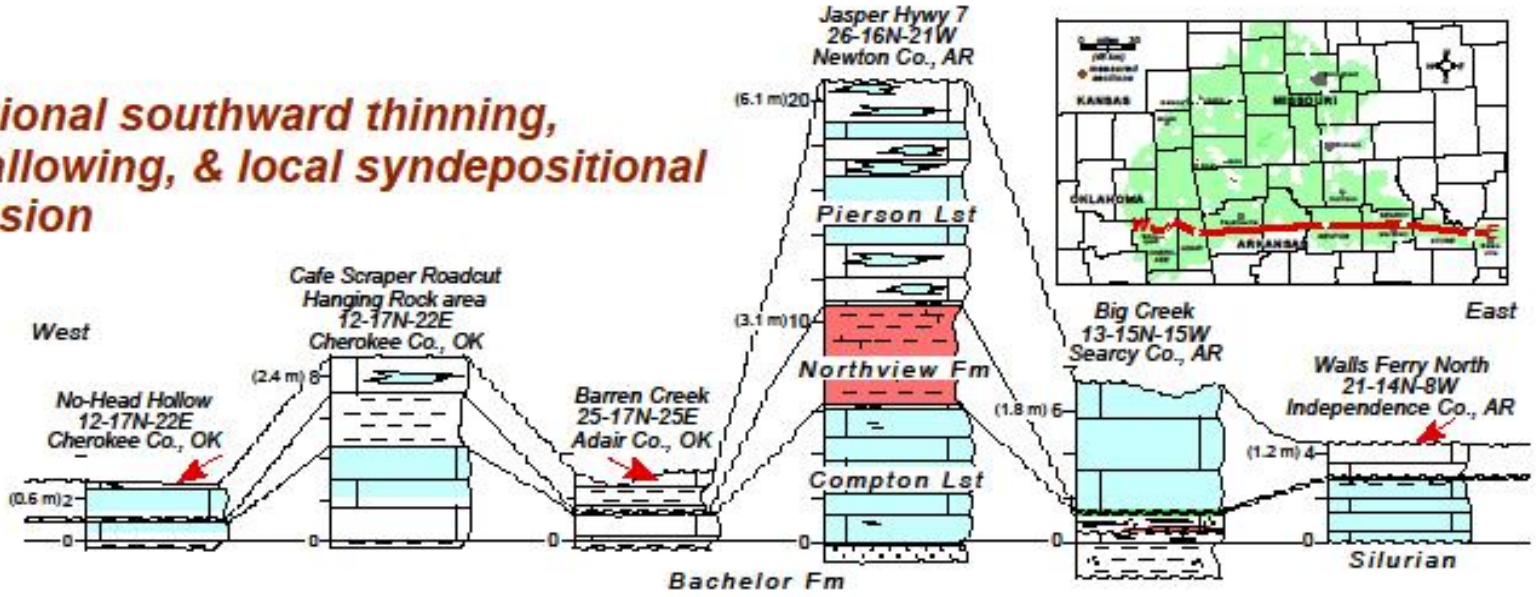




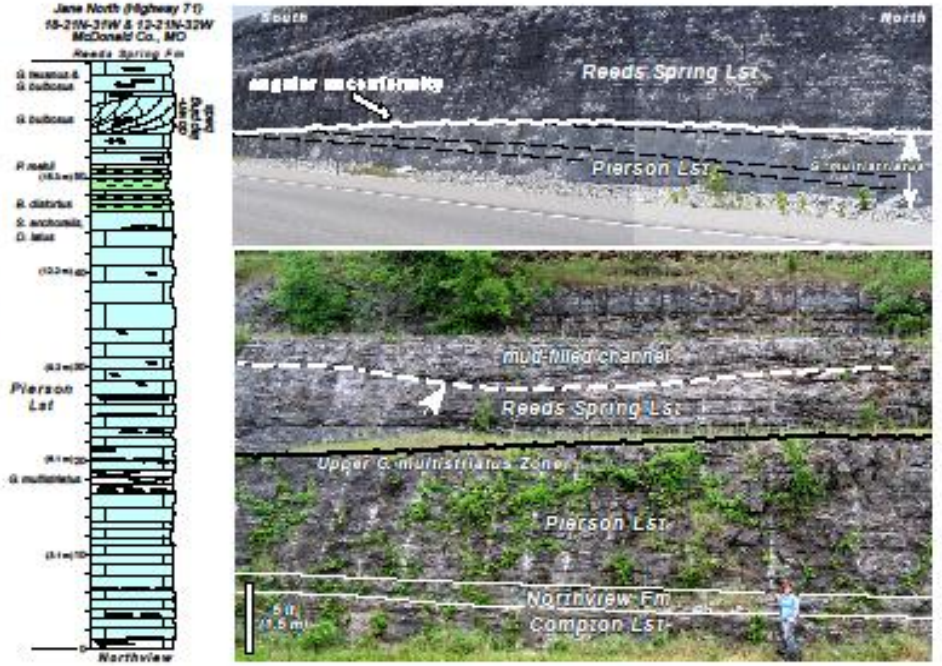


RESULTANT STRATIGRAPHIC ARCHITECTURE OF ST. JOE GROUP IN OUTCROPS

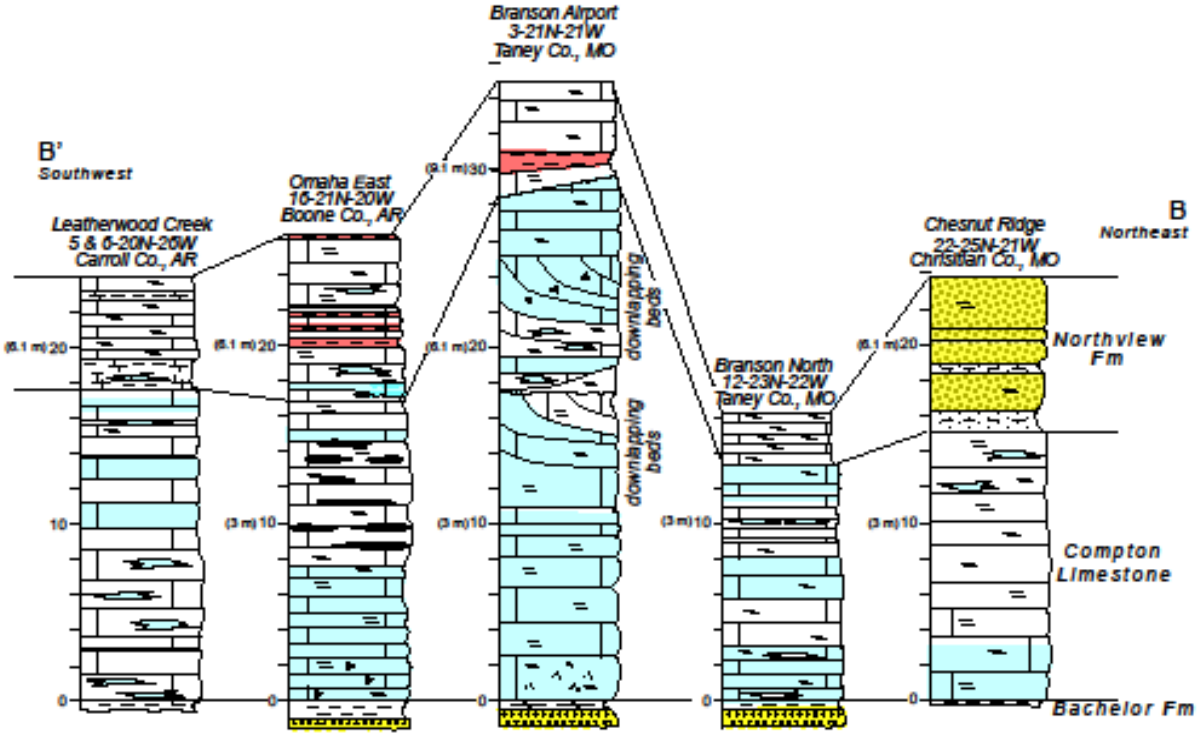
regional southward thinning, shallowing, & local syndepositional erosion



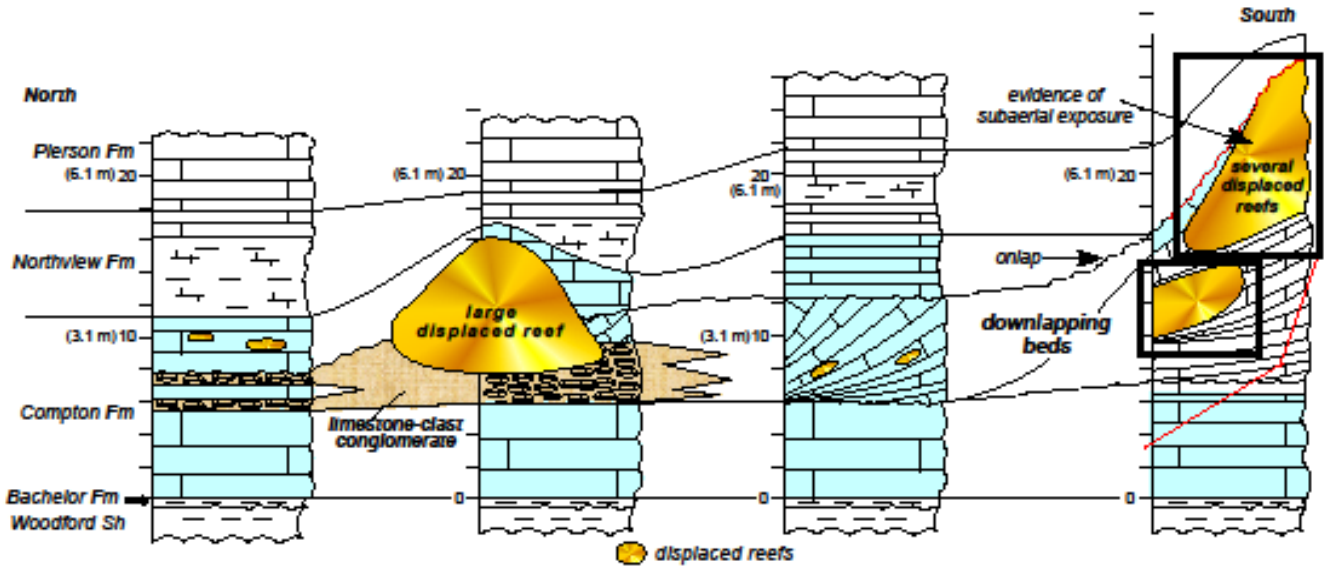
pronounced local uplift and deep, syndepositional erosion



north-dipping clinoforms

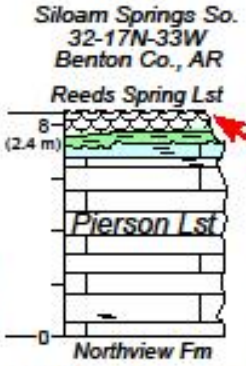


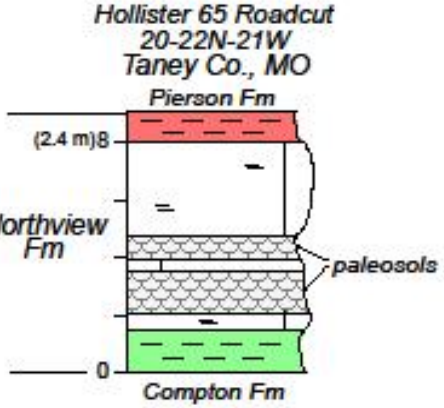
associated with displaced reefs

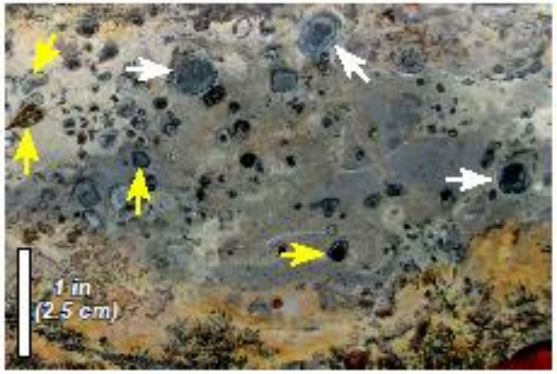


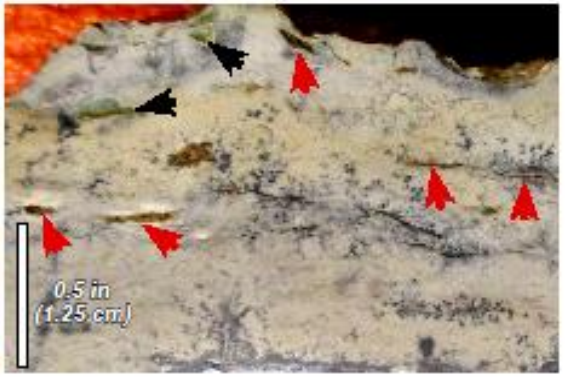
paleosols in the Northview & Pierson Fms

areal extent of Pierson paleosols defines a paleotopographic high

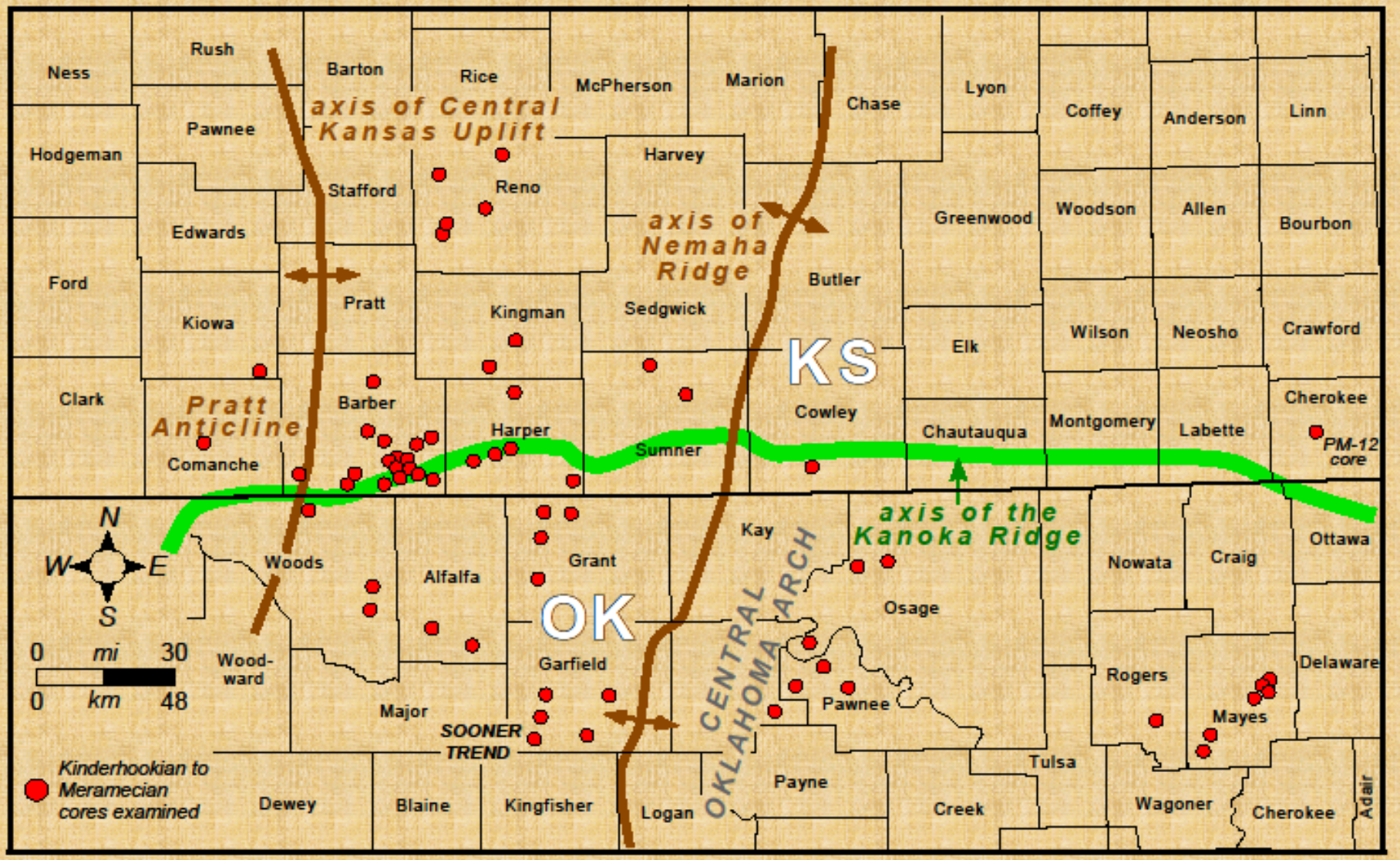






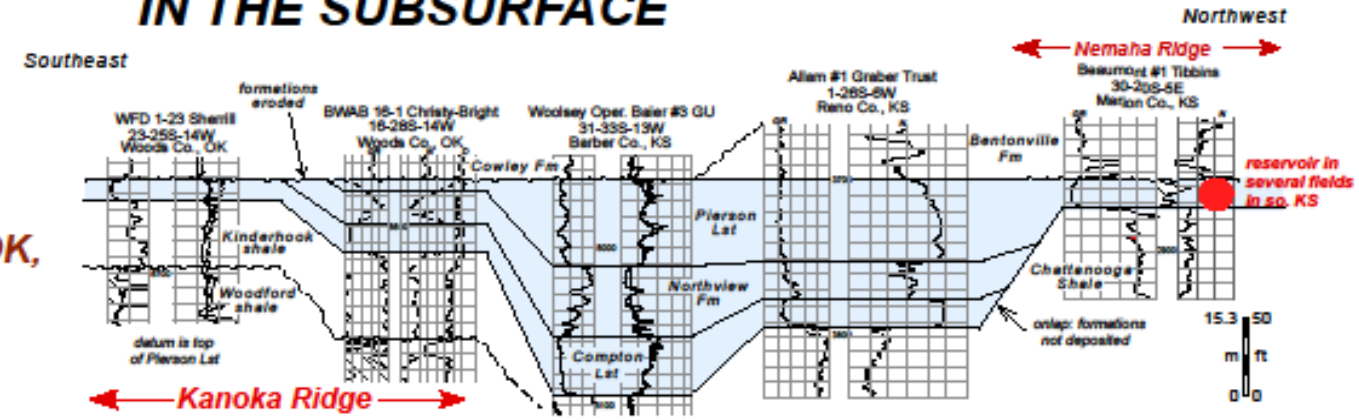


SUBSURFACE KS-OK CORE DATA BASE

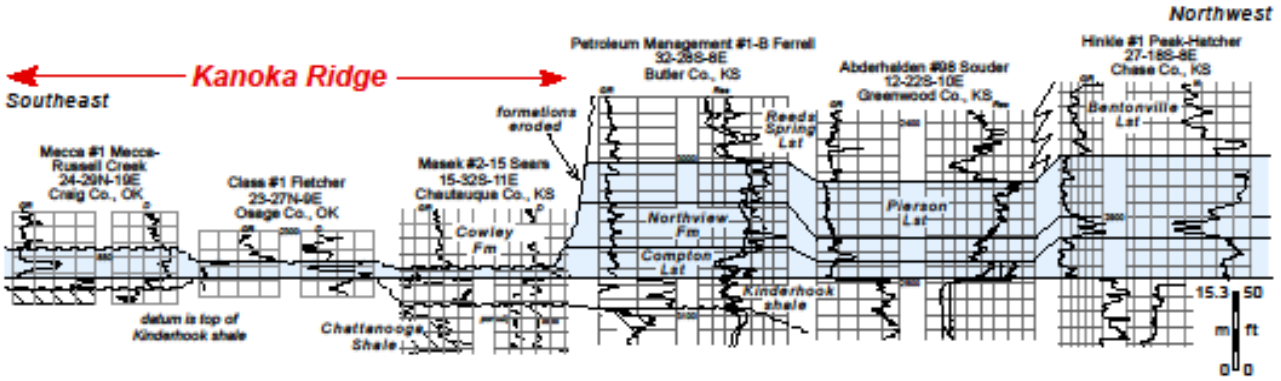


ARCHITECTURE AND FACIES OF ST. JOE GROUP IN THE SUBSURFACE

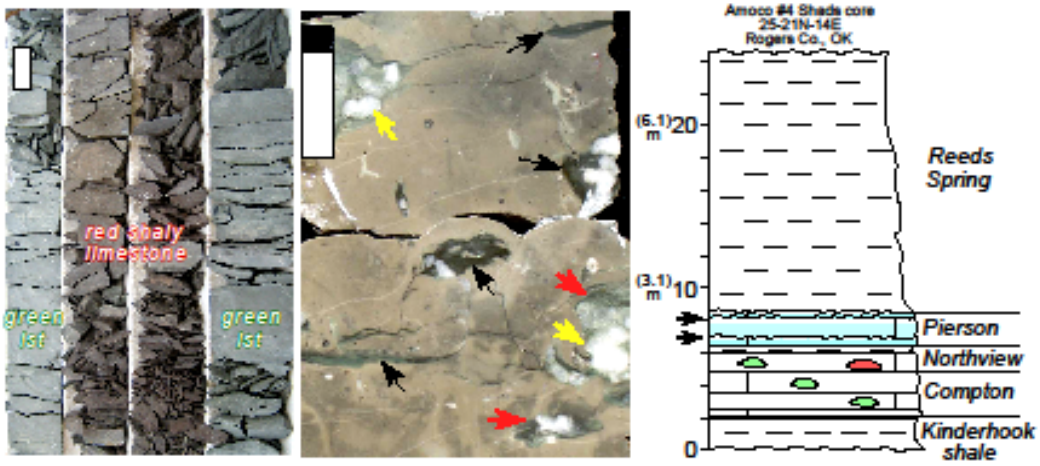
paleotopographic high in southern KS & northern OK, northward tilting of shelf



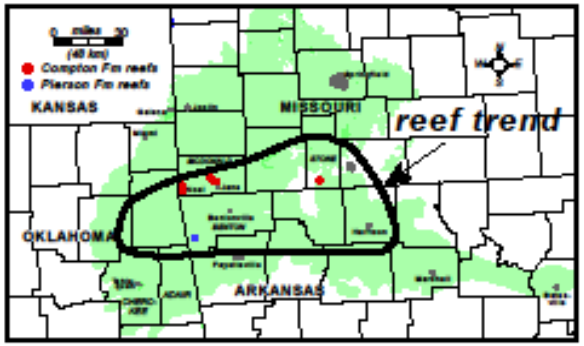
deep erosion in southern KS & northern OK



shallow-water facies to the south



REEFS IN OUTCROPS

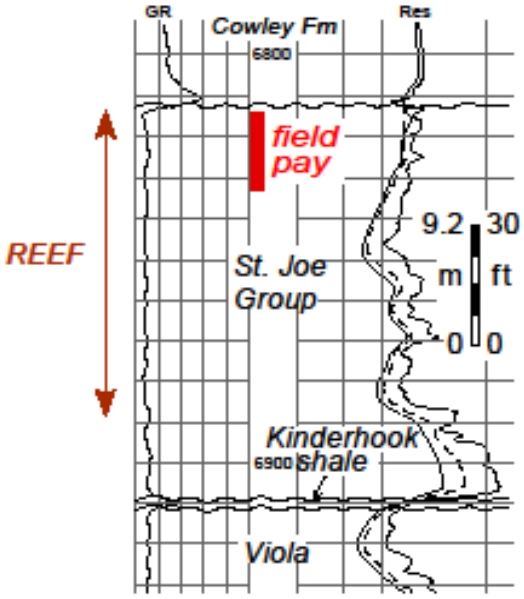


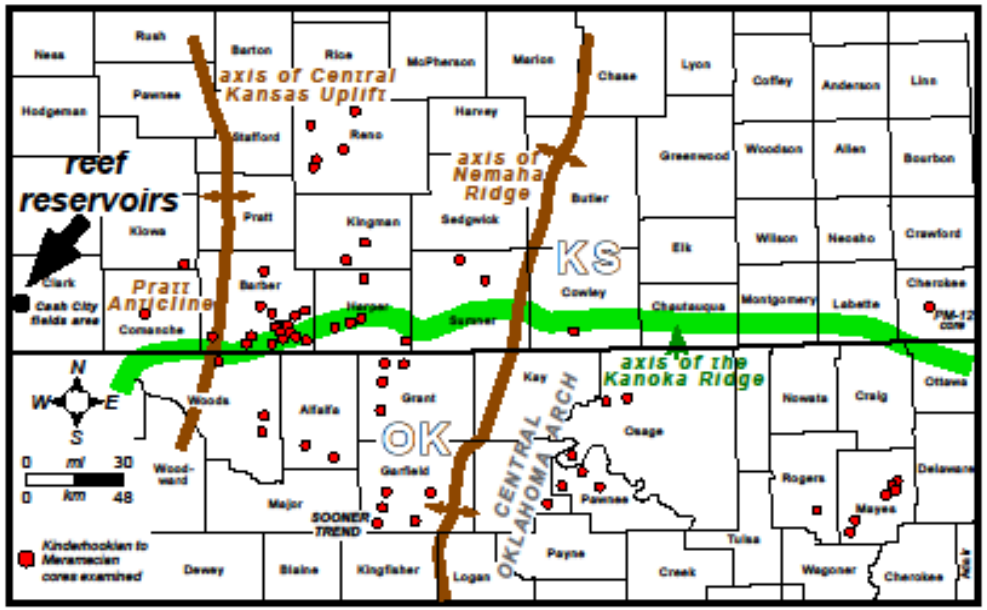
reefs are bryozoan-crinoid bafflestones with secondary dissolution porosity formed during subaerial meteoric exposure

SUBSURFACE REEF RESERVOIRS

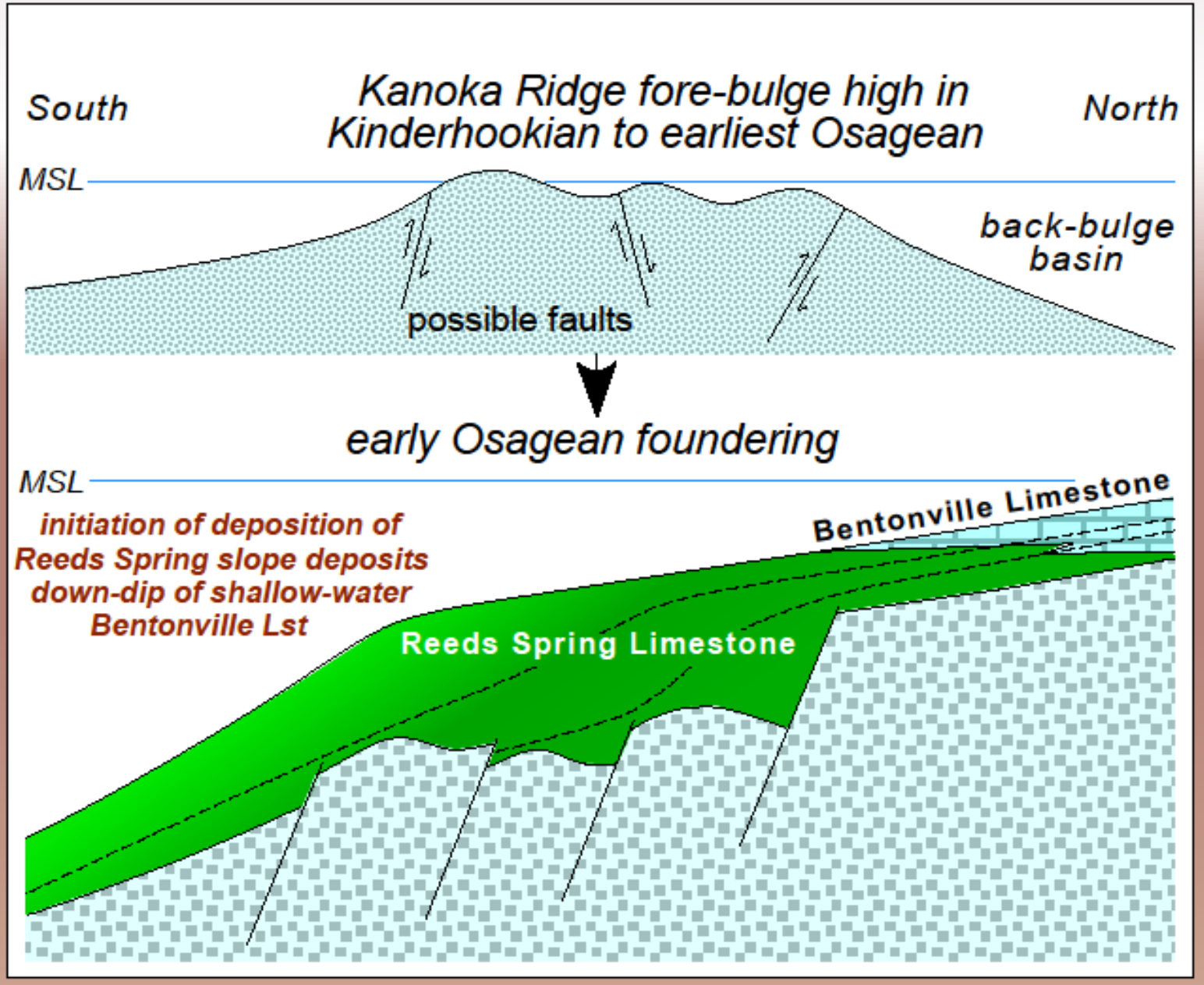
Midco #2-18 Theis
18-33S-25W
Clark Co., KS

in Kansas, similar bryozoan-crinoid reefs in the St. Joe Group are present in an ~E-W trend in eastern Meade, Clark, and Comanche Counties

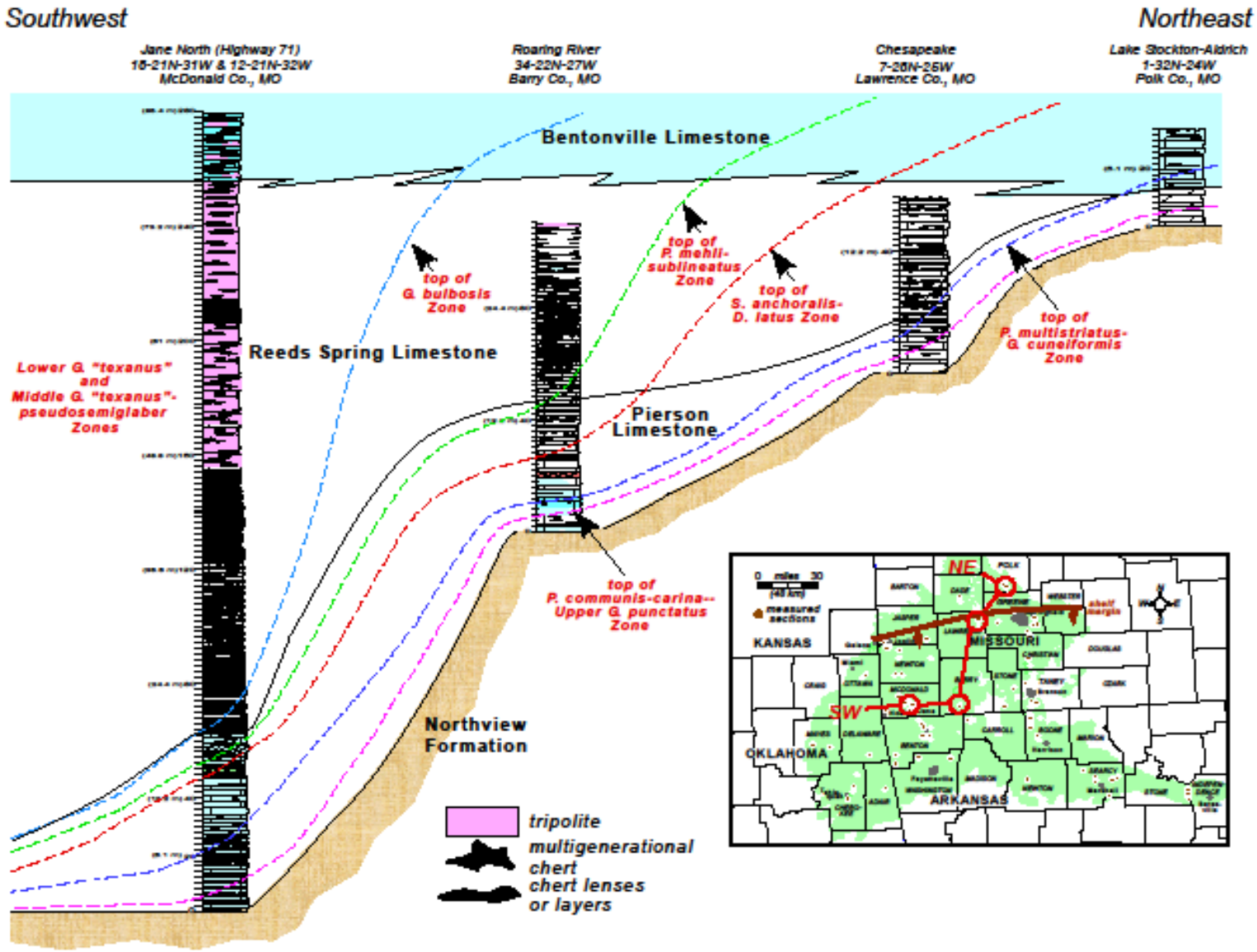




FOUNDERING OF KANOKA RIDGE AND RAPID SUBSIDENCE



PROGRADATIONAL SHELF-TO-SLOPE SYSTEM OF THE BENTONVILLE AND REEDS SPRING-UPPER PIERSON LIMESTONES



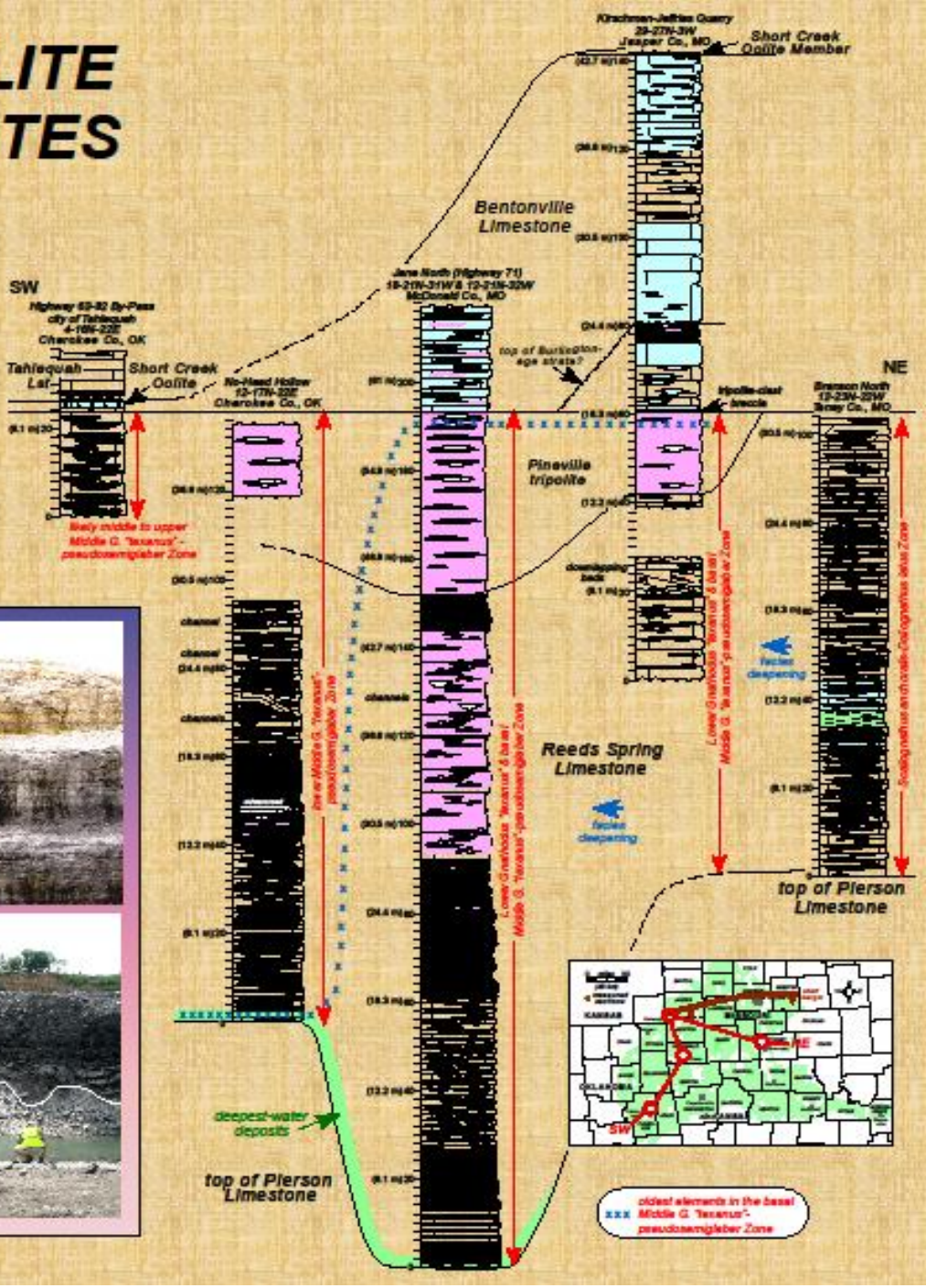
REEDS SPRING LITHOLOGY AND DEPOSITIONAL SYSTEMS

PINEVILLE TRIPOLITE ORIGIN & ATTRIBUTES IN OUTCROPS

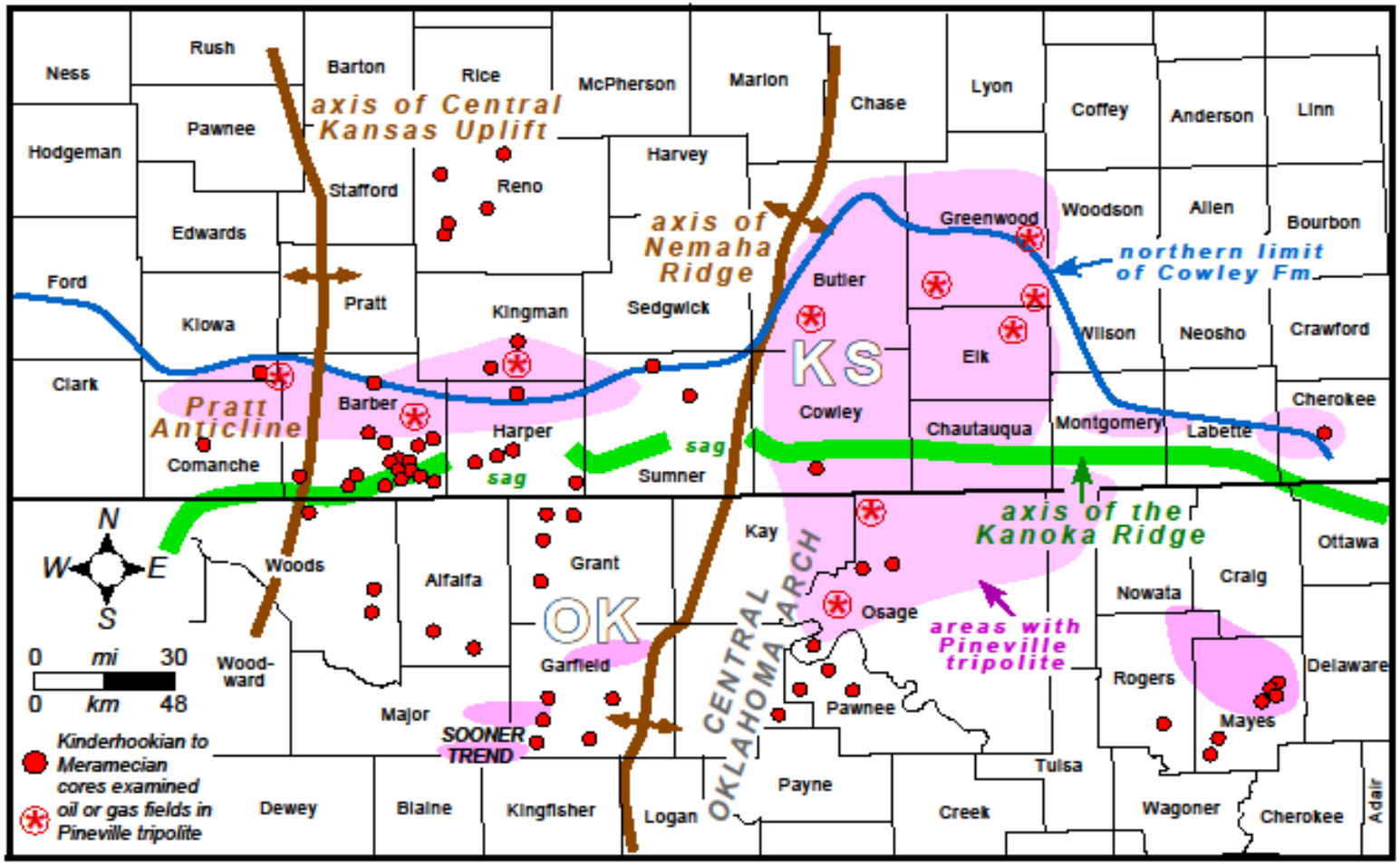
areal distribution in outcrops

replaces the upper Reeds Spring Lst

subsequent pre-Meramecian tripolite erosion



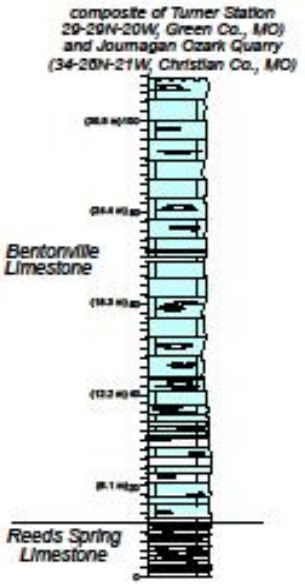
SUBSURFACE TRIPOLITE



- *it is an oil/gas reservoir at a number of fields*
- *it is not present everywhere at the top of the Reeds Spring Lst because of pre-Meramecian erosion*
- *erosionally-thinned Bentonville Lst up-dip of the Reeds Spring Lst includes reservoirs in tripolitized chert breccia*

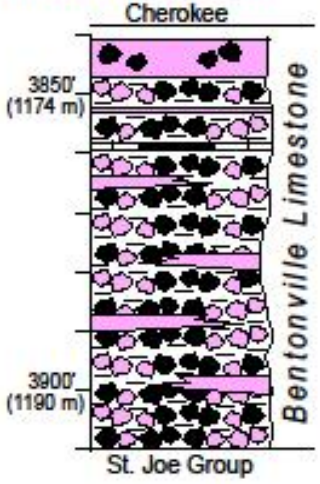
BENTONVILLE LIMESTONE IN OUTCROPS

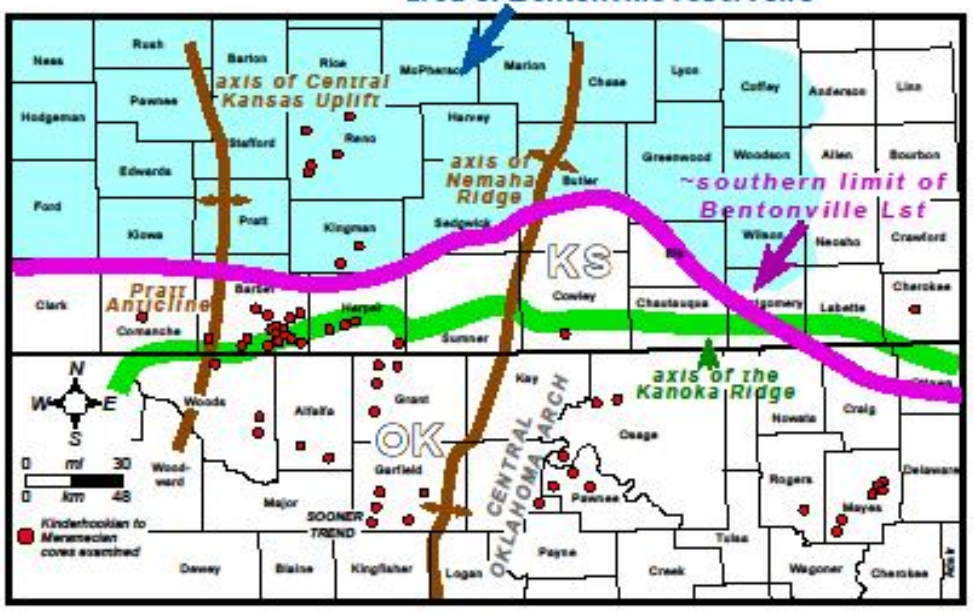
comprises ~100-140 ft of coarse-grained skeletal sands with little to no porosity and no reefs



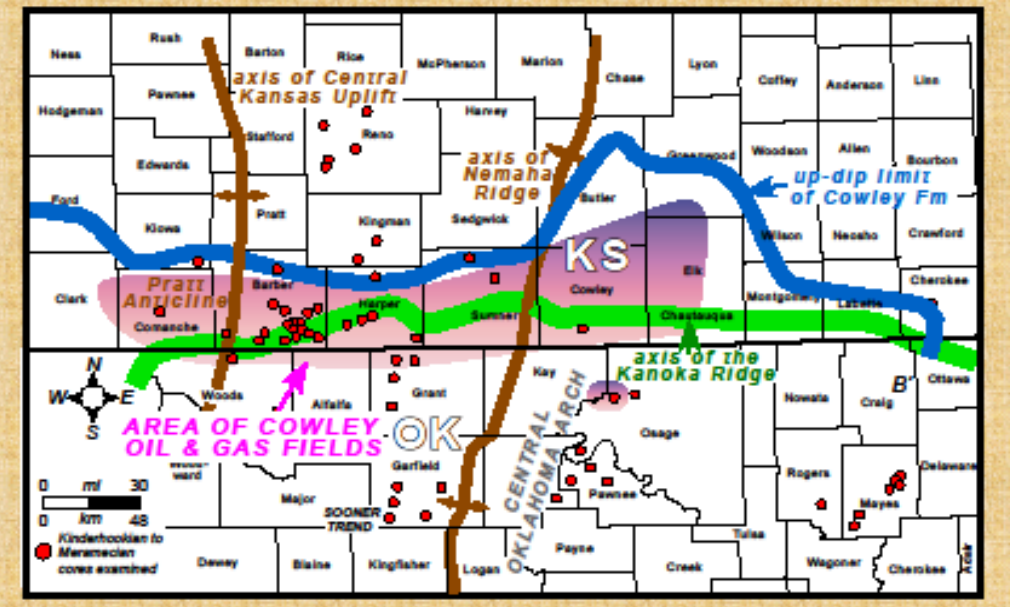
RESERVOIRS IN THE SUBSURFACE

chert breccias, locally tripolitic and shaly, in erosionally very thin Bentonville sections



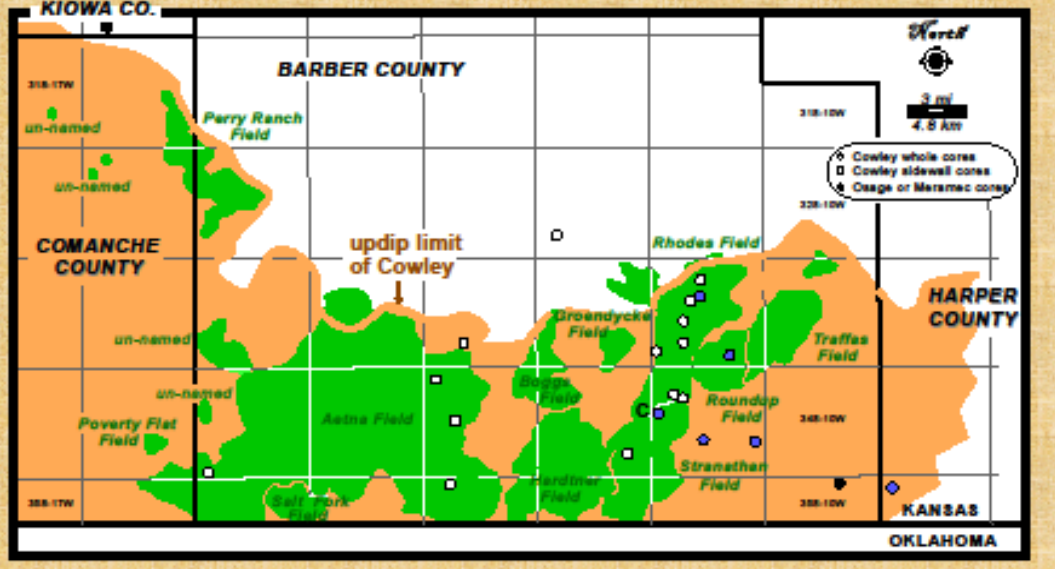


COWLEY FORMATION (BASAL MERAMECIAN): STRICTLY A SUBSURFACE UNIT

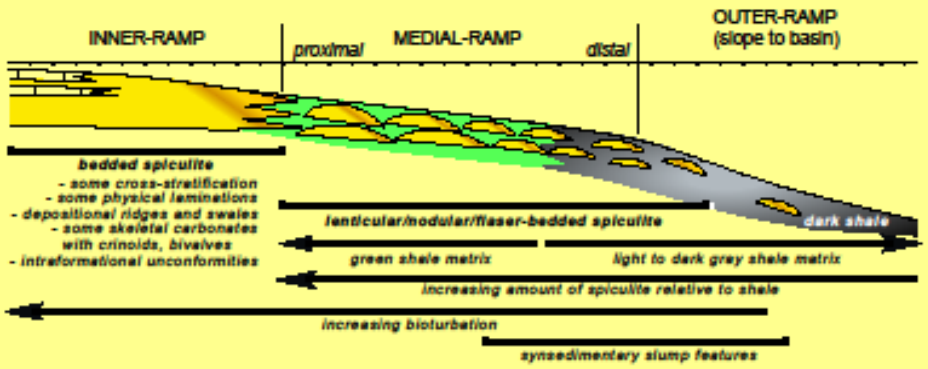


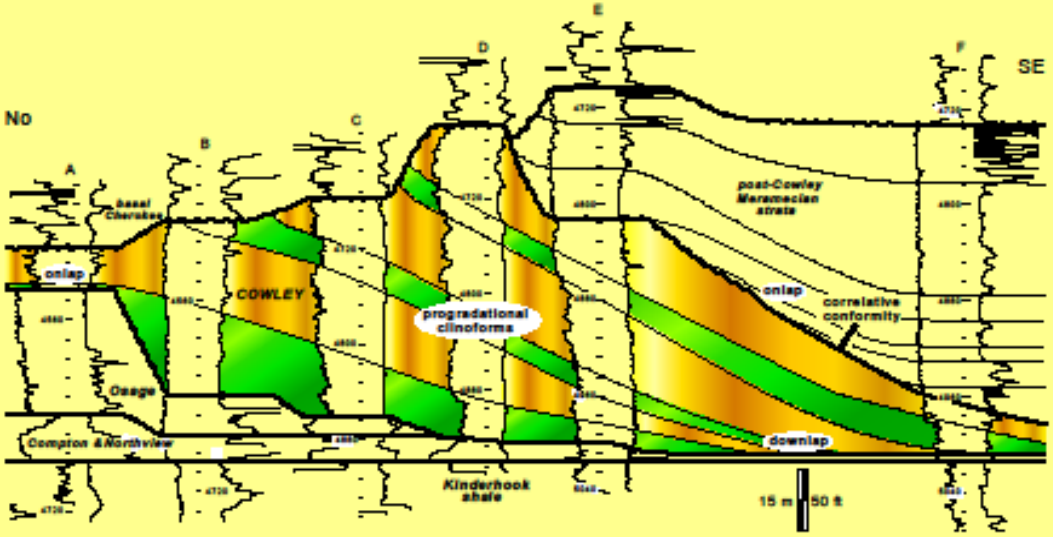
A SPICULITE-DOMINATED UNIT -- likely reflects a time of suppressed carbonate sediment production possibly resulting from ocean acidification

a number of fields produce from the Cowley Formation in south-central Kansas



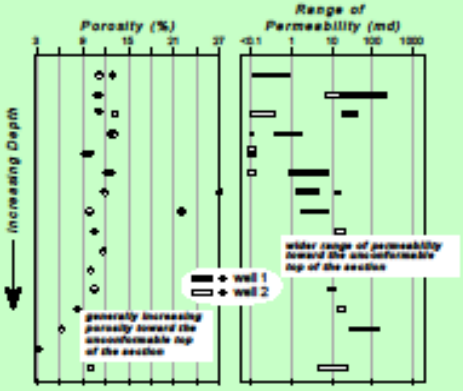
COWLEY DEPOSITIONAL SYSTEM

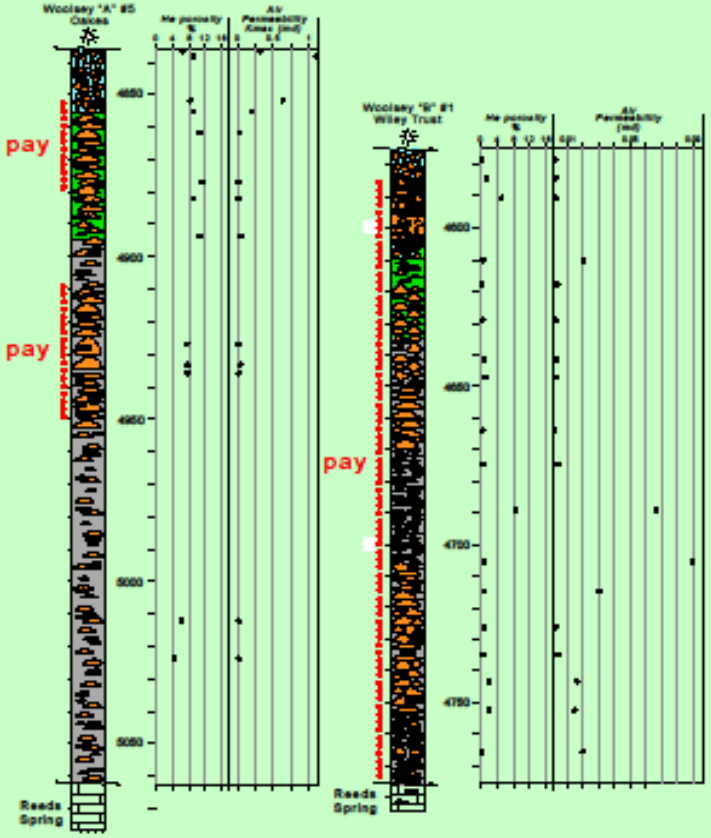




Cowley is a progradational sequence bounded by unconformities

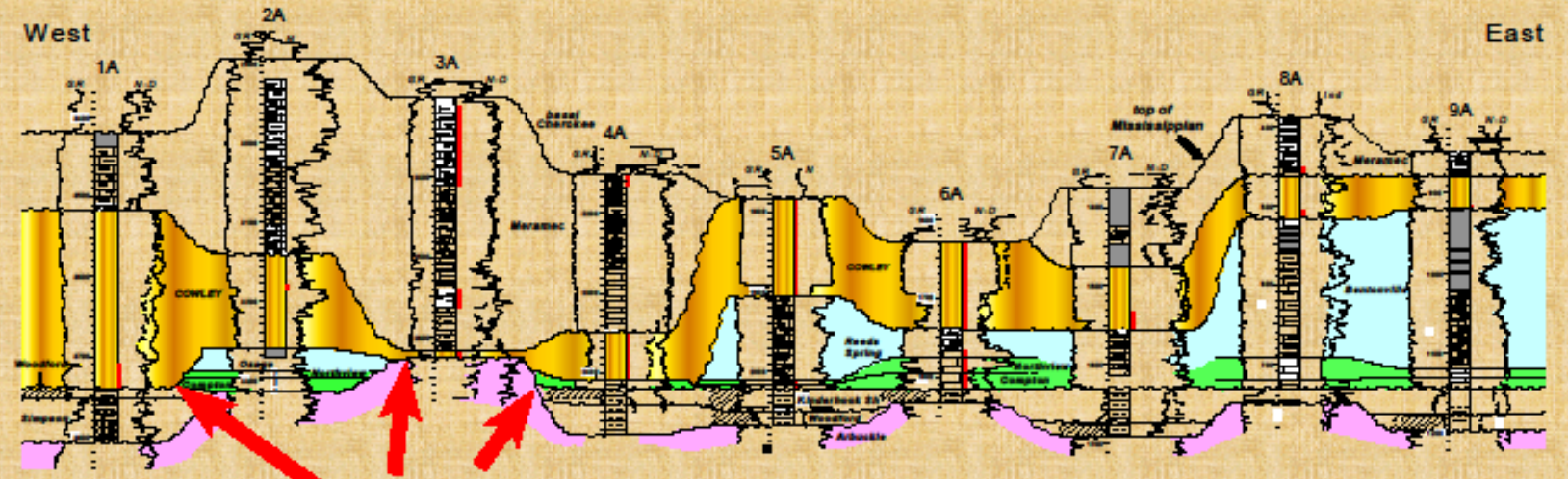
COWLEY RESERVOIRS



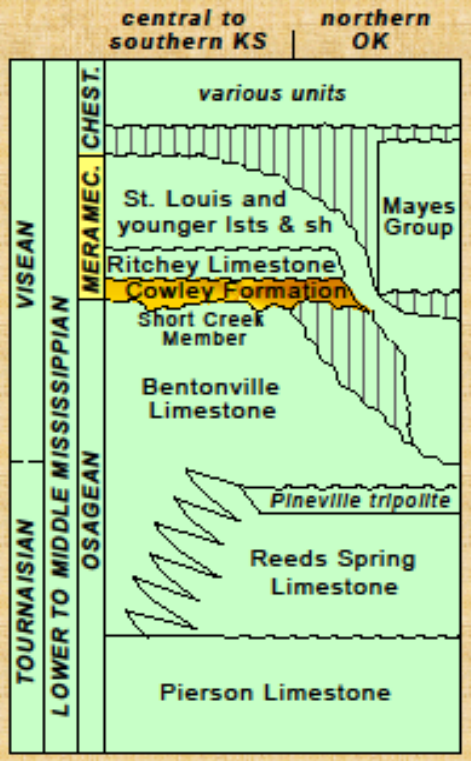


pay may be present throughout the section

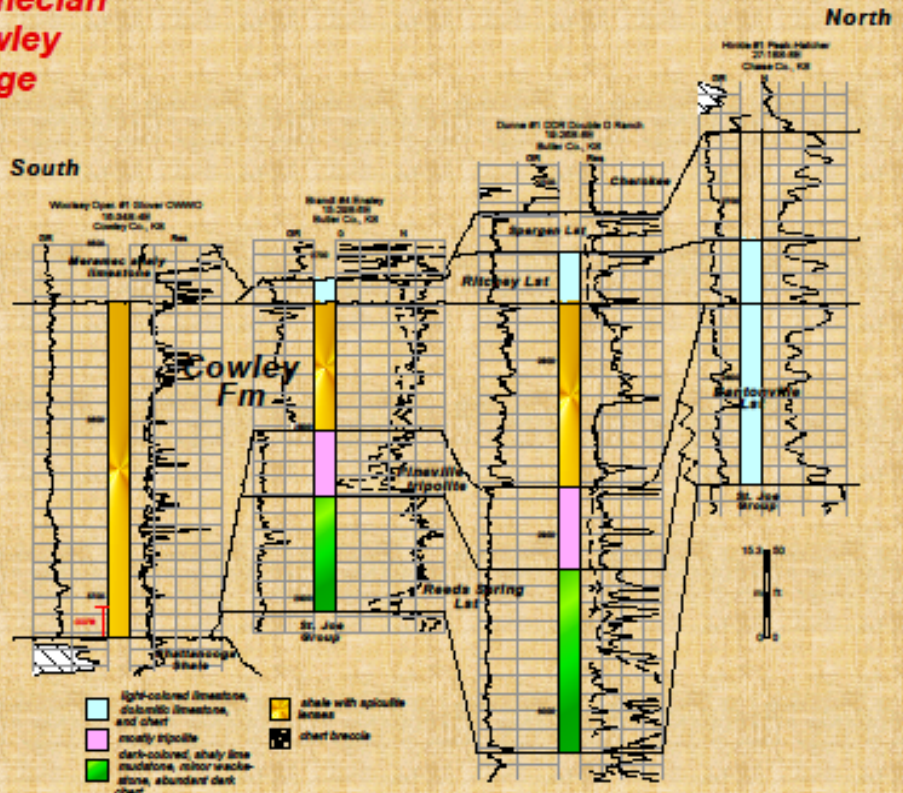
TECTONO-STRATIGRAPHIC SETTING OF COWLEY FM

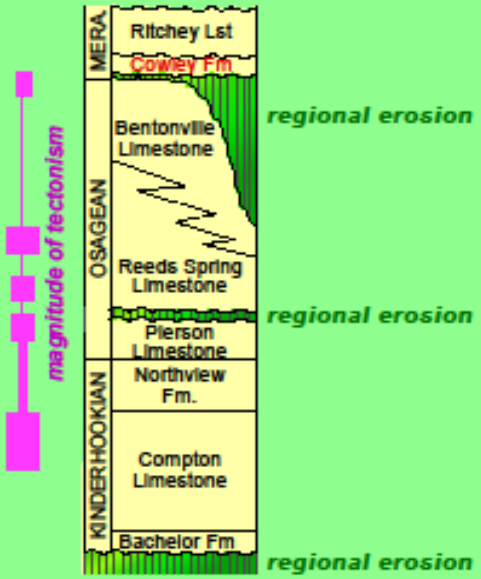


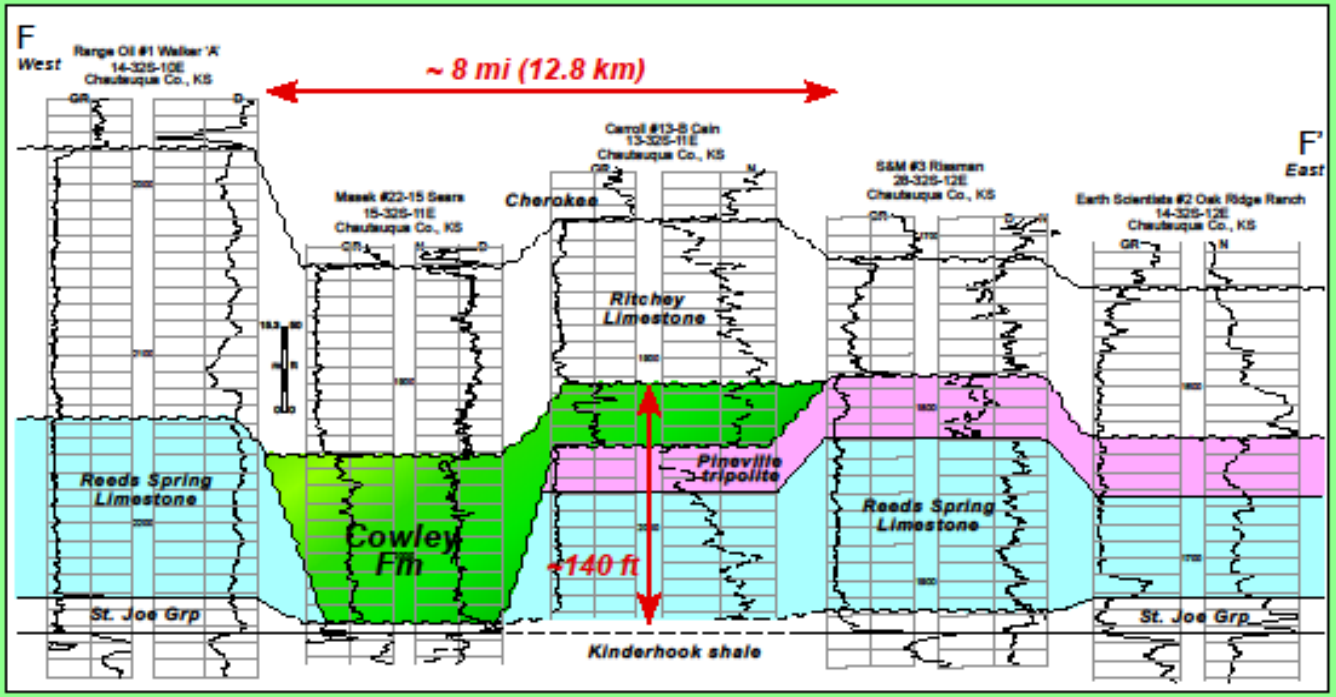
deep pre- or early Meramecian erosion at base of Cowley along the Kanoka Ridge



Cowley is overlain by Ritchey (Warsaw) Lst and erosionally truncates the Bentonville and Reeds Spring lsts

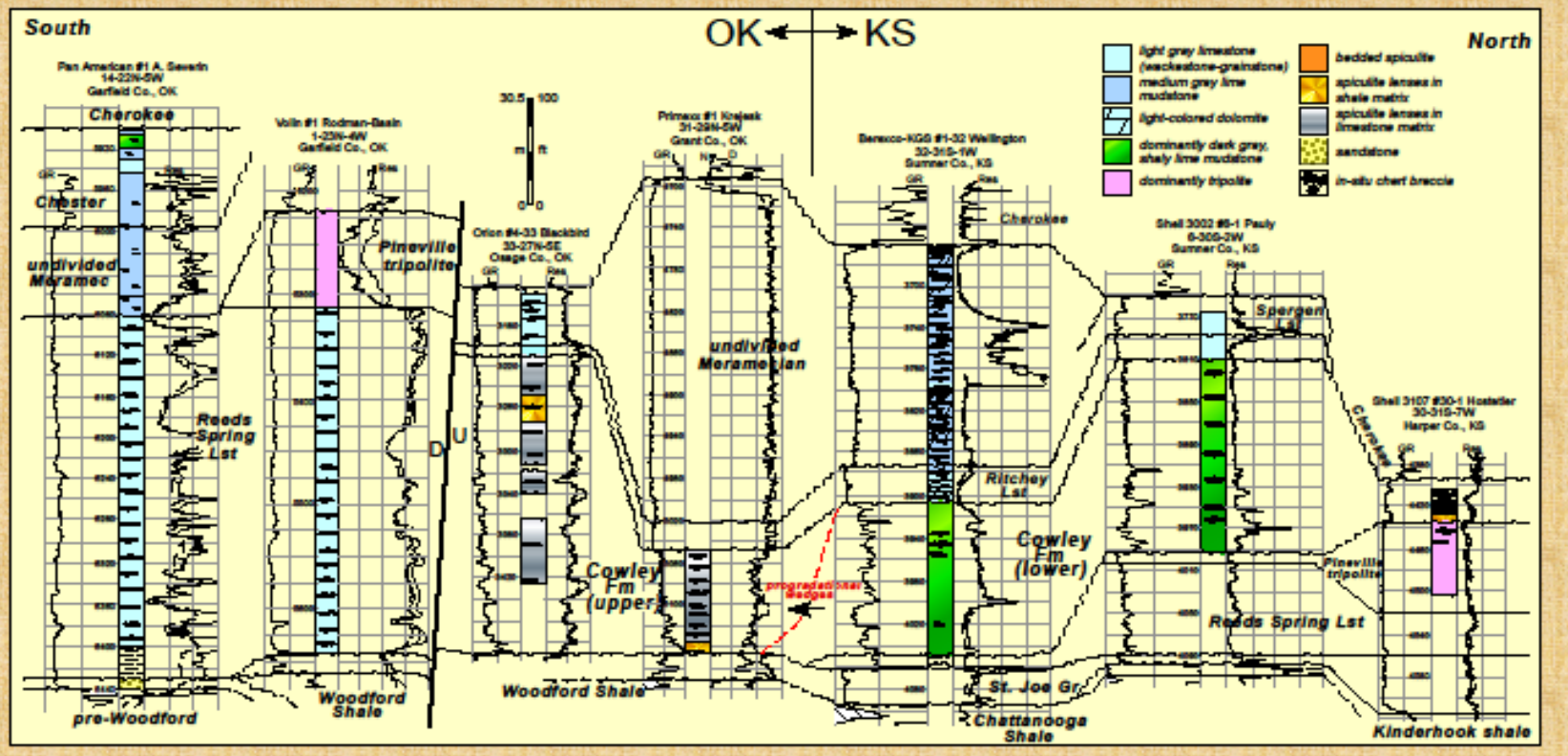


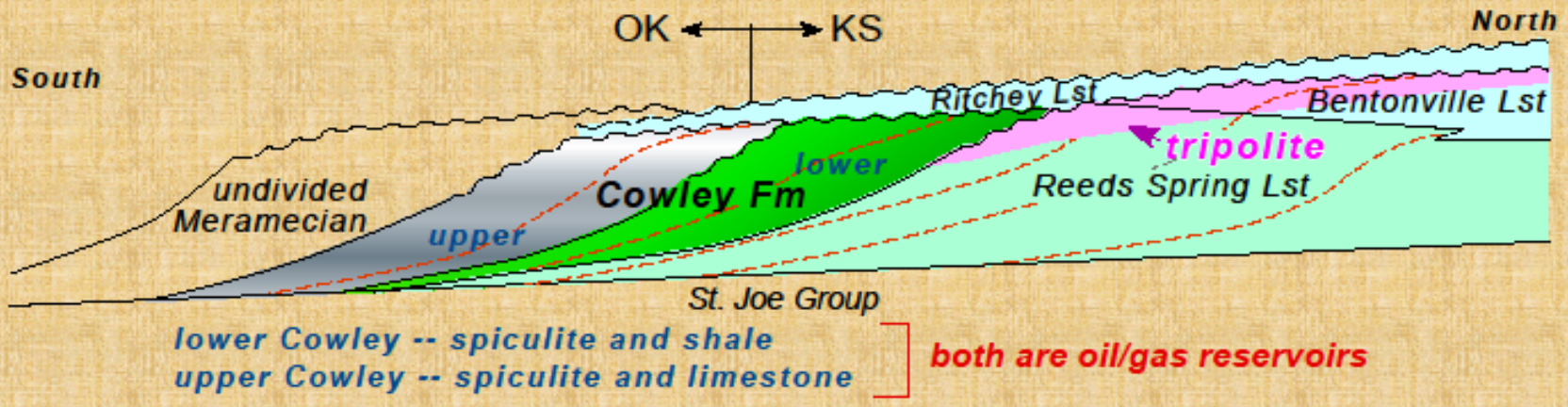




COWLEY WAS DEPOSITED IN VALLEYS & OTHER LOWS WHEREIN THE BENTONVILLE LST WAS LARGELY ERODED. SUCH UPLIFT AND DEEP EROSION IN SOUTHERN KANSAS & NORTHERN OKLAHOMA OCCURRED DURING THE LATEST OSAGEAN(?) & EARLIEST MERAMECIAN

CHANGING COWLEY LITHOLOGIES OVER TIME





lower Cowley -- spiculite and shale
upper Cowley -- spiculite and limestone

both are oil/gas reservoirs

CONCLUDING REMARKS

- *Outcrops of Lower to Middle Mississippian rocks in Missouri, Arkansas and Oklahoma indeed are an analog of correlative subsurface strata*
- *Subsurface lithostratigraphy and reservoirs in KS and OK were affected by syndepositional tectonism as in outcrops*
- *The Kanoka Ridge, a paleotopographic high extant during the Kinderhookian and early Osagean, is also present in the subsurface. It foundered during the Osagean, and resulted in a pulse of subsidence and consequent pro-gradation of upper Osagean shelf and slope limestones*
- *The basal Meramecian Cowley Fm is strictly a subsurface unit that was deposited on a deeply eroded surface of the former Kanoka Ridge*
- *Younger Meramecian rocks in northern Oklahoma are a progradational section of shallow and deeper-water lime-stones and shales that require conodont biostratigraphic study and regional identification/correlation*