Potential Reef Reservoir Objectives in the Lower Mississippian St. Joe Group (Kinderhookian to Basal Osagean) in Southern Kansas*

Beau Morris[1], Sal Mazzullo[2], and Brian White[3]

Search and Discovery Article #50889 (2013)**
Posted November 25, 2013

*Adapted from oral presentation given at AAPG Mid-Continent Section Meeting, Wichita, Kansas, October 12-15, 2013

[1]Outlaw Exploration, LLC, Wichita, KS (morrisgeo@me.com)
[2]Mazzullo Exploration, LLC, Wichita, KS (sjmazzullo@gmail.com)
[3]Woolsey Corp., Wichita, KS (bwilhite@woolseyco.com)

Abstract

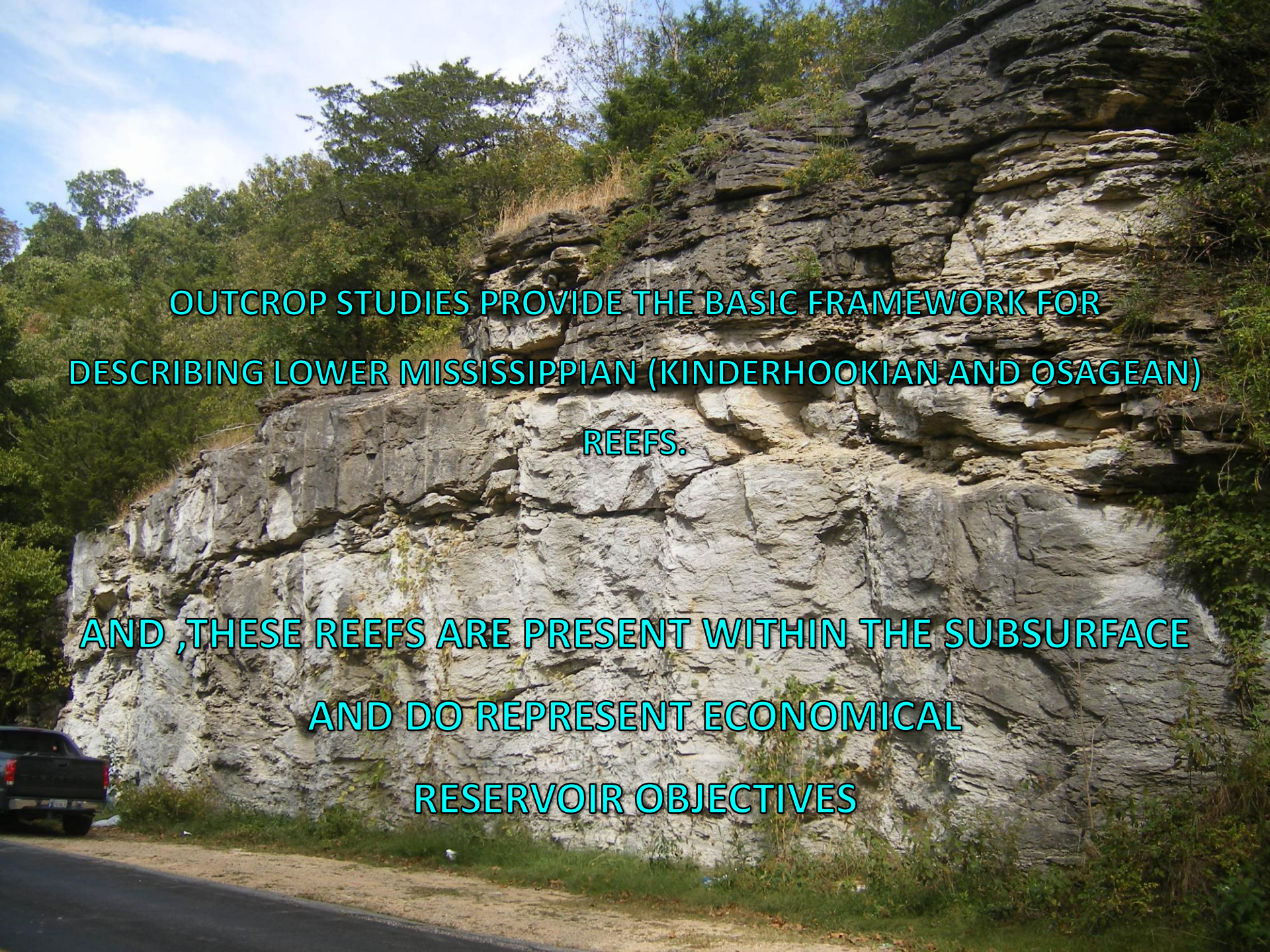
Porous reef limestones, commonly with significant oil shows, are present in outcrops of the St. Joe Group in SW Missouri and NW Arkansas. Specifically, the reefs are present in the Compton and Pierson formations, and reefs are not known to be developed in the intervening Northview Formation. These reef occurrences are analogs of potential petroleum reservoirs in subsurface Kansas. The reefs are developed on south-sloping ramps, particularly where they intersect topographically positive seafloor features related to syndepositional Ouachita tectonism. They were constructed by fenestrate bryozoans and crinoids, and porosity therein was related to post-depositional subaerial exposure and meteoric dissolution. In the subsurface of southern Kansas, indications of reefing in the Compton and Pierson formations in similar locations on their respective ramps are: (i) abrupt thickening of these units as indicated on wireline logs and (ii) concomitant development of high porosity, and (iii) the presence of reef facies in some cores. Petroleum reservoirs in such rocks are most likely to dominantly be depositional-facies traps associated with overlying tight limestone or shale seals. Late Kinderhookian and early Osagean erosion, however, locally may impart some degree of paleotopographic trap development on these potential reservoirs. Oil production from such reef facies is known from some fields in northern Oklahoma, and a play for these rocks may extend into southern Kansas.

POTENTIAL REEF RESERVOIR OBJECTIVES IN THE LOWER MISSISSIPPIAN ST. JOE GROUP (KINDERHOOKIAN TO BASAL OSAGEAN) IN SOUTHERN KANSAS

BEAU T. MORRIS, OUTLAW EXPLORATION, LLC | morrisgeo@me.com

S. J. MAZZULLO, MAZZULLO EXPLORATION, LLC | sjmazzullo@gmail.com

BRIAN W. WILHITE, WOOLSEY CORP., | bwilhite@woolseyco.com


OUTCROP STUDIES PROVIDE THE BASIC FRAMEWORK FOR
DESCRIBING LOWER MISSISSIPPIAN (KINDERHOOKIAN AND OSAGEAN)
REEFS.
AND ,THESE REEFS ARE PRESENT WITHIN THE SUBSURFACE
AND DO REPRESENT ECONOMICAL
RESERVOIR OBJECTIVES

HEREIN, WE INTEND TO SHOW

THROUGH

-Outcrop examination: establishing a internal architecture (including development of porosity) and a depositional framework.

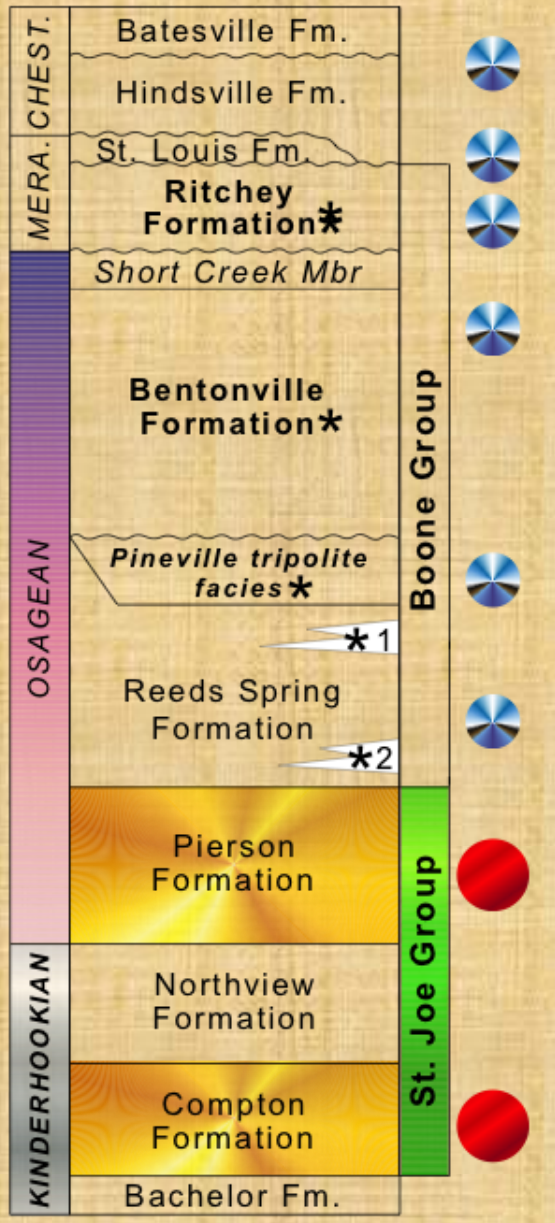
-Thereby, providing a temporal model of reefs on the outcrop serving as a reservoir analog for the subsurface

-Wireline logs, cores, and well cuttings;

- And production from such reefs in southern Kansas fields.

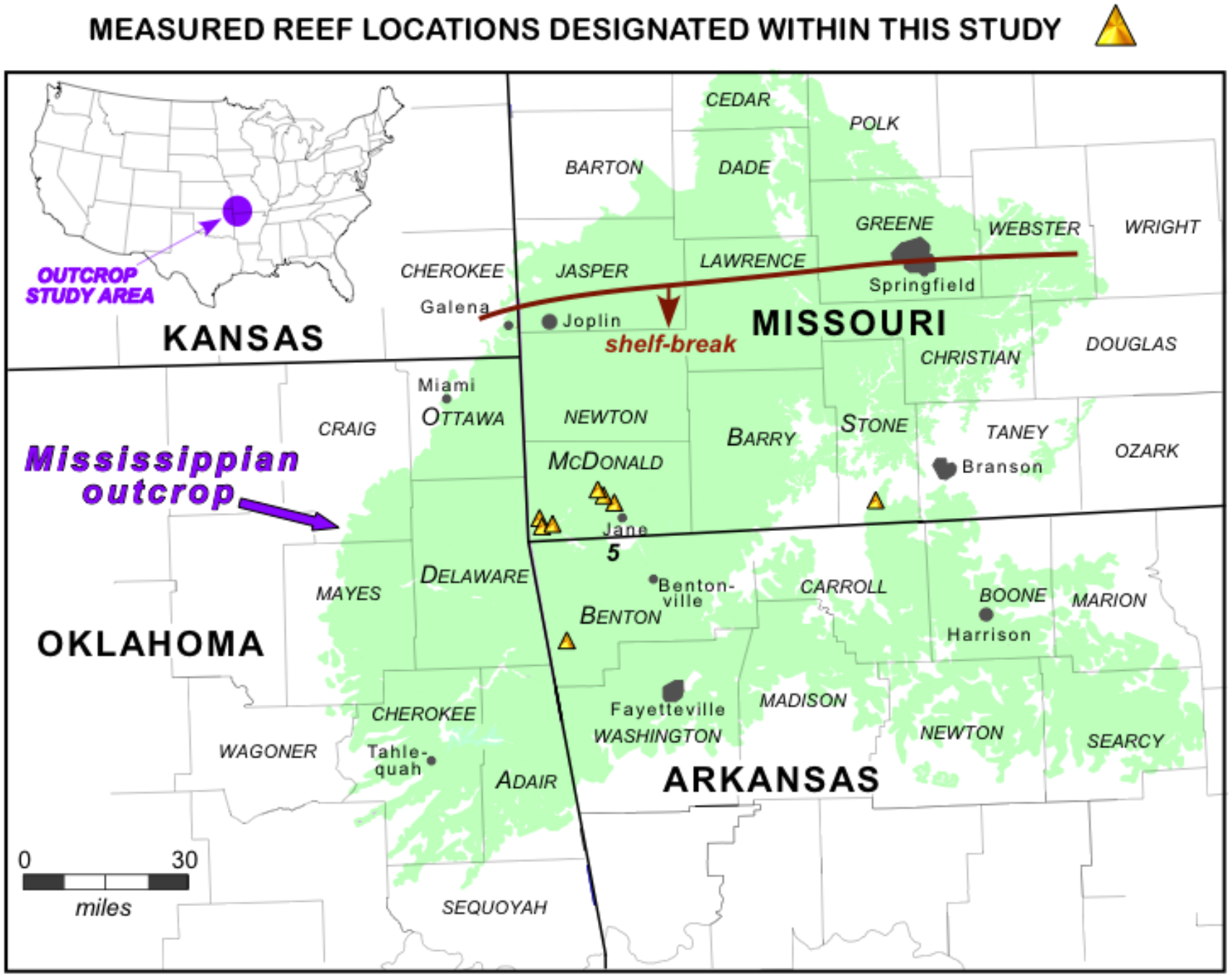
REEFS ARE PRESENT AND SUBSURFACE RESERVOIRS

MISSISSIPPIAN OUTCROP AND SUBSURFACE STRATIGRAPHIC TERMINOLOGY

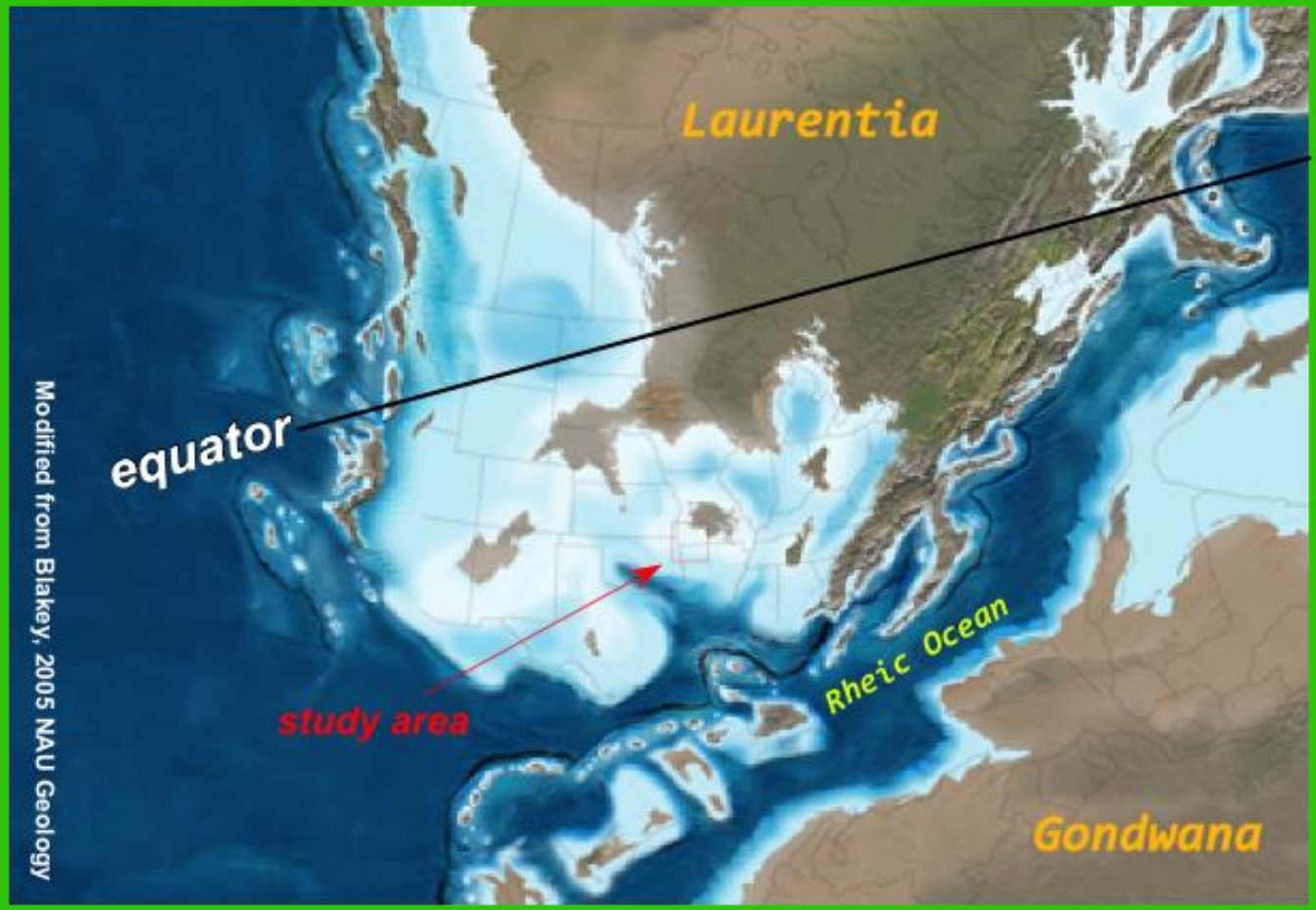


Mazzullo et. al., (2013)

CIRCLES DENOTE KNOWN <u>PRODUCING RESERVOIRS PRESENT</u> WITHIN THE SUBSURFACE OF SOUTHERN AND SOUTH CENTRAL KANSAS

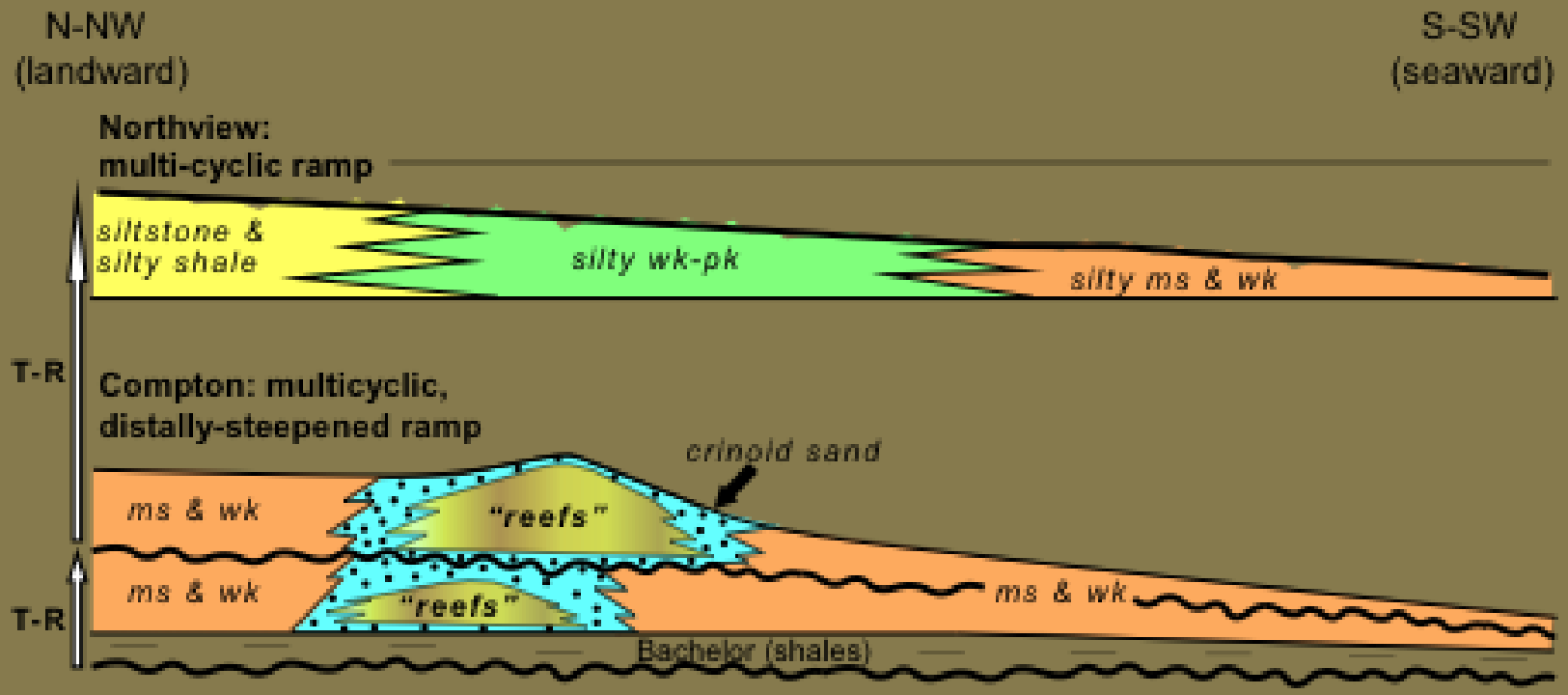

MEASURED REEF LOCATIONS DESIGNATED WITHIN THIS STUDY
OUTCROP STUDY AREA
KANSAS
MISSOURI
OKLAHOMA
ARKANSAS
shelf-break
Mississippian outcrop
CEDAR
POLK
BARTON
DADE
GREENE
WEBSTER
WRIGHT
CHEROKEE
JASPER
LAWRENCE
Springfield
Galena
Joplin
CHRISTIAN
DOUGLAS
Miami
CRAIG
OTTAWA
NEWTON
BARRY
STONE
TANEY
OZARK
McDONALD
Branson
Jane
5
DELAWARE
MAYES
Benton-ville
CARROLL
BOONE
MARION
BENTON
Harrison
CHEROKEE
Fayetteville
MADISON
WASHINGTON
NEWTON
SEARCY
WAGONER
Tahle-quah
ADAIR
SEQUOYAH
0
30
miles

The typically accepted, quiescent or tectonically inactive paleogeographic representation of early Mississippian (Kinderhookian and Osagean) time.



HOWEVER……..We now know this to be untrue as evidence of syndepositional tectonism has overprinted early Mississippian rocks exposed on the outcrop and is present within those same time equivalent rocks westward in the subsurface.

DEPOSITIONAL ARCHITECTURE OF COMPTON REEFS

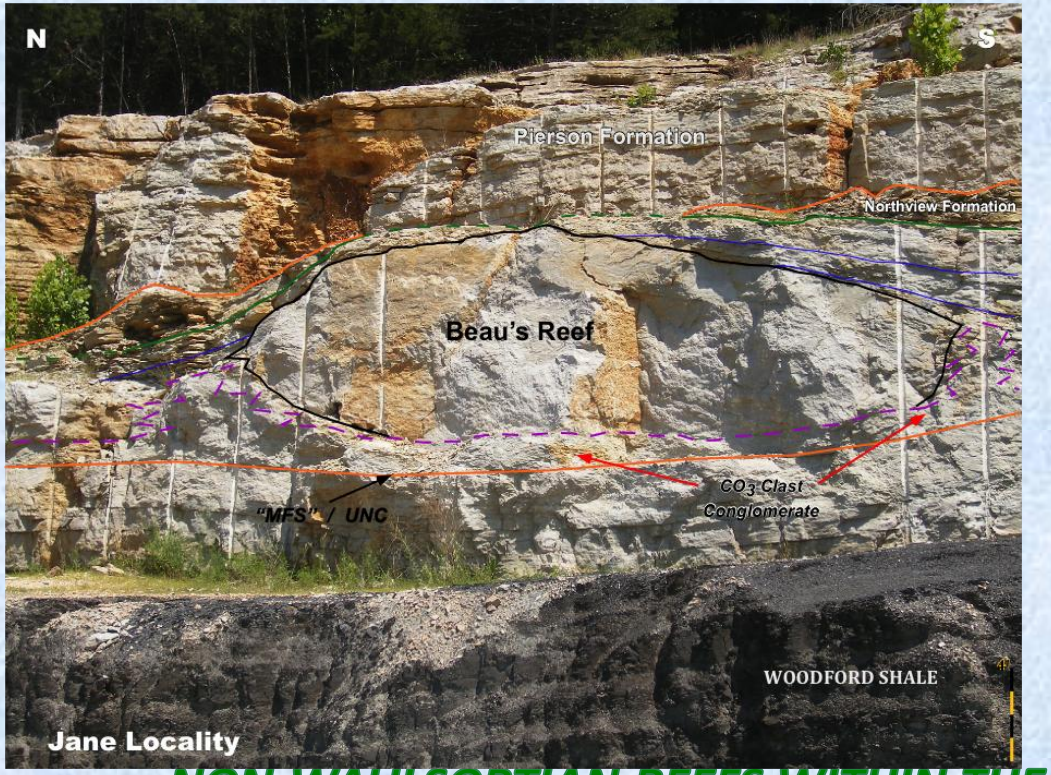


aggradational ramps with reefs in medial ramp environments

Waulsortian-like reefs within the Compton Formation

Including stromatactis as above, and those without stromatactis bryozoan to crinoid muddy bafflestone types at right.

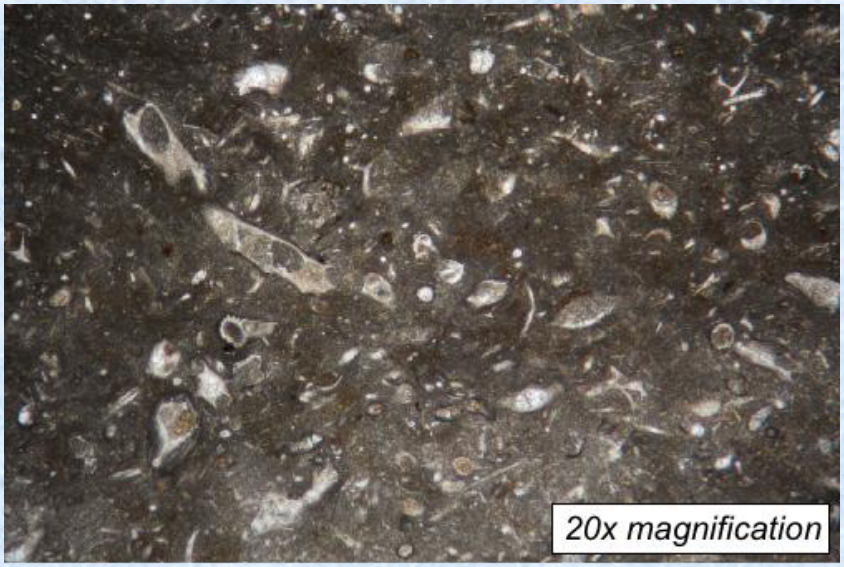
Tabular - Flat Bottom Convex Top Shapes between 5' - 30' thick on outcrop



NON-WAULSORTIAN REEFS WITHIN THE COMPTON FORMATION

WAULSORTIAN-LIKE REEFS RECOGNITION OF INTERNAL FRAMEWORK AND PETROGRAPHY

Bryozoan rich reef matrix

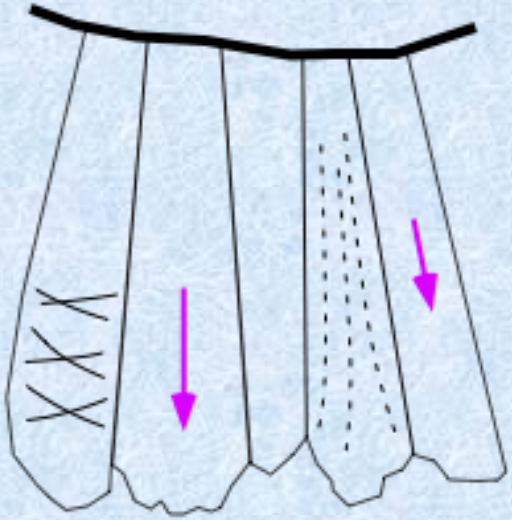


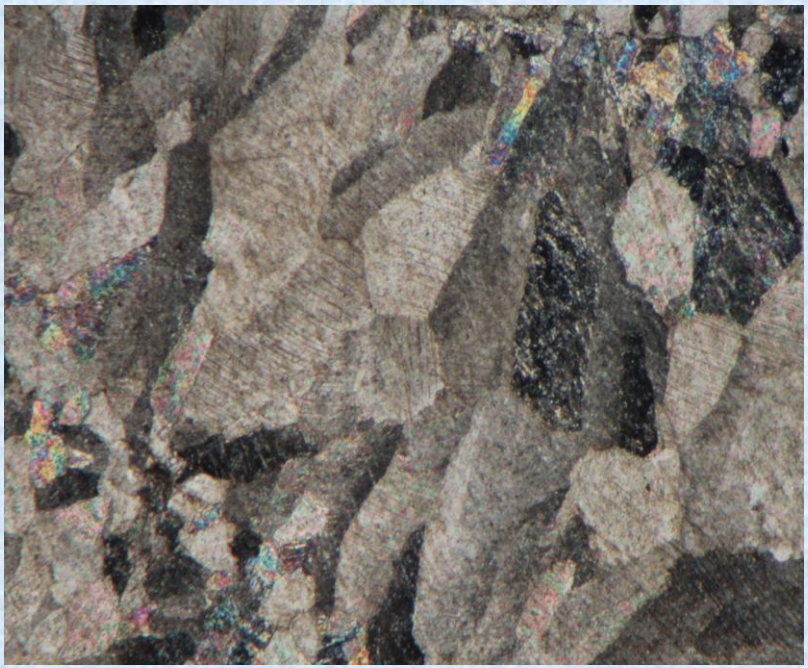
Photomicrograph Compton reef matrix. cross polars

RFC filling stromatactis

outcrop photo of stromatactis and dissolutional vugs

RADIAXIAL FIBROUS CALCITE "MARINE CEMENTS"





cross polars *20x magnification*

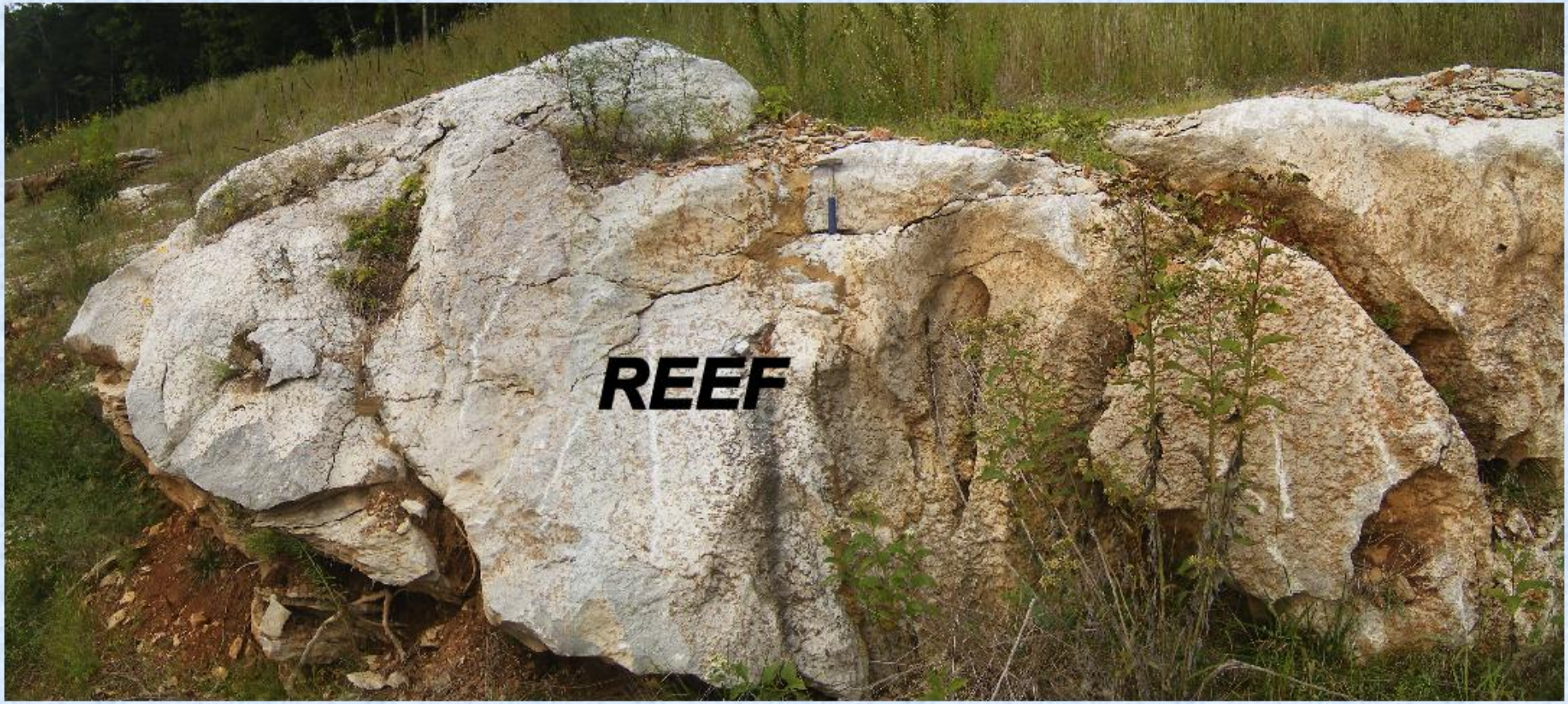
Photomicrograph of RFC **MARINE CEMENTS** filling *stromatactis*, 20x magnification, cross polars

these cement fabrics are characteristic of Mississippian reefs

Waulsortian-like

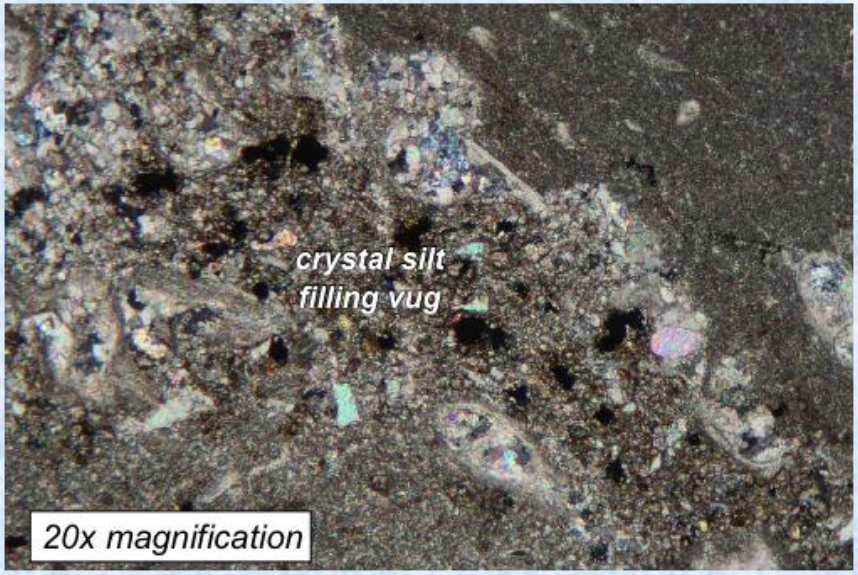
BRYOZOAN – CRINOID MUDDY BAFFLESTONE REEFS

INTERNAL FRAMEWORK AND PETROGRAPHY

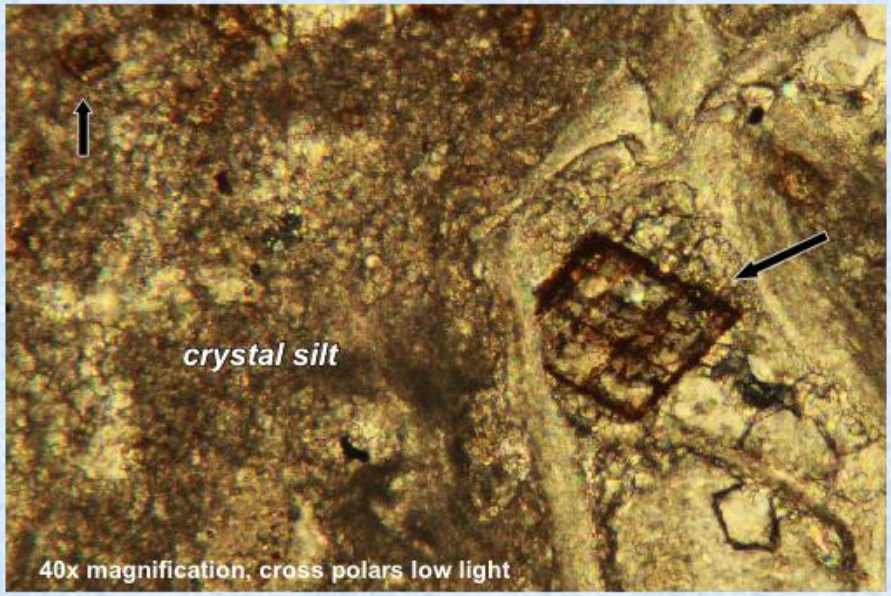


similar lithologic and biologic assemblages; however, without stromatactis and RFC

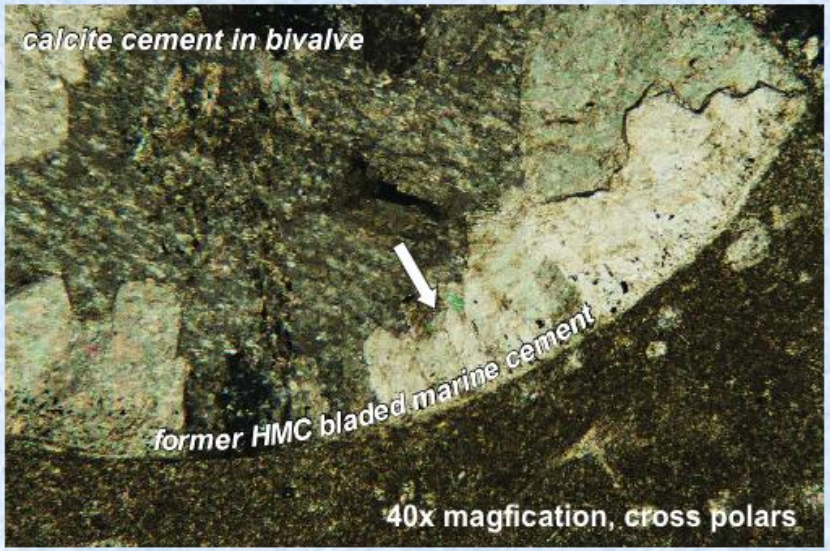
Evidence of Unconformity



Photomicrograph of internal vadose crystal silt filling a vug, later occluded by coarse pore filling calcite. cross polars



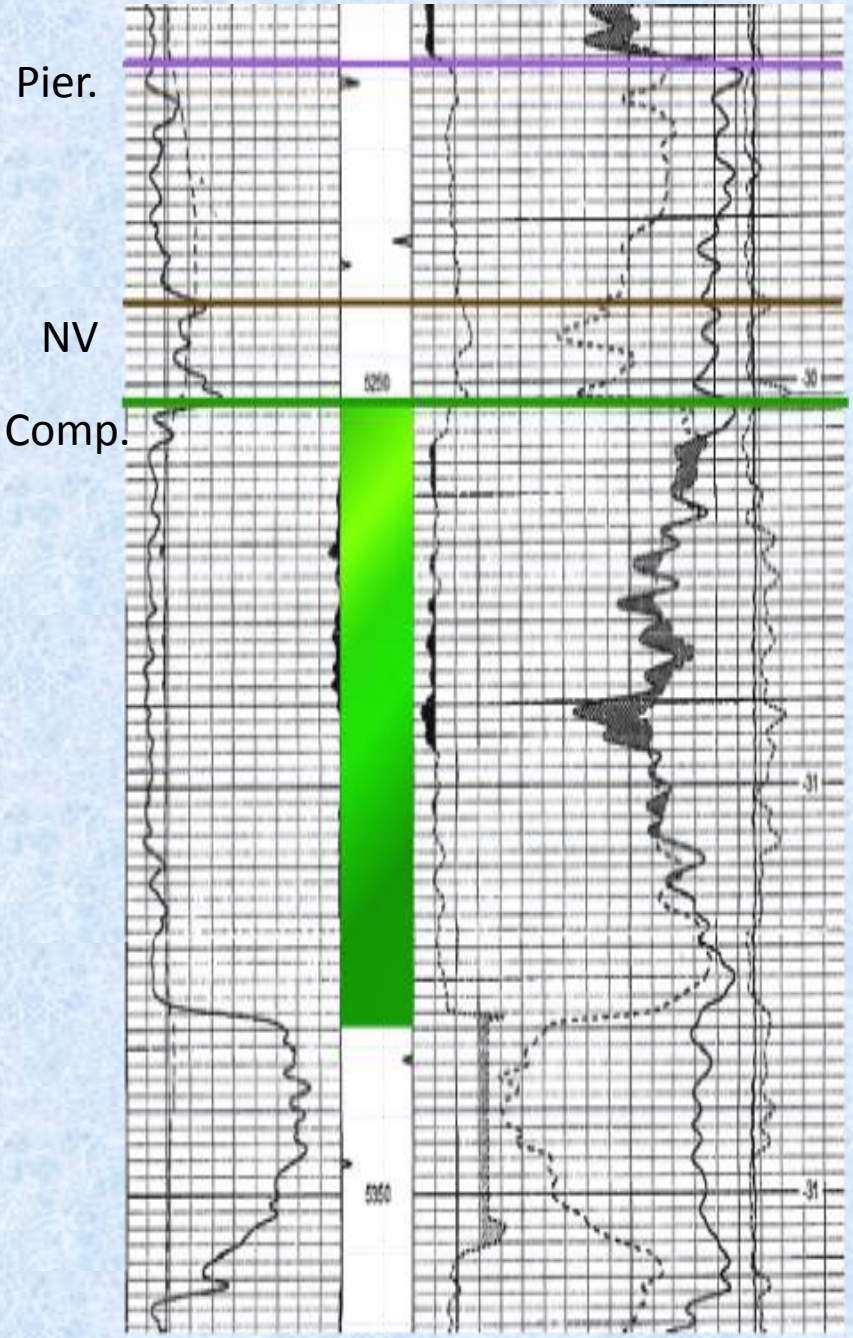
internal vadose crystal silt:
eroded marine cements & biotic particles forming "crystal silt" DIRECTLY RELATED TO SUBAERIAL EXPOSURE Dunham, 1969



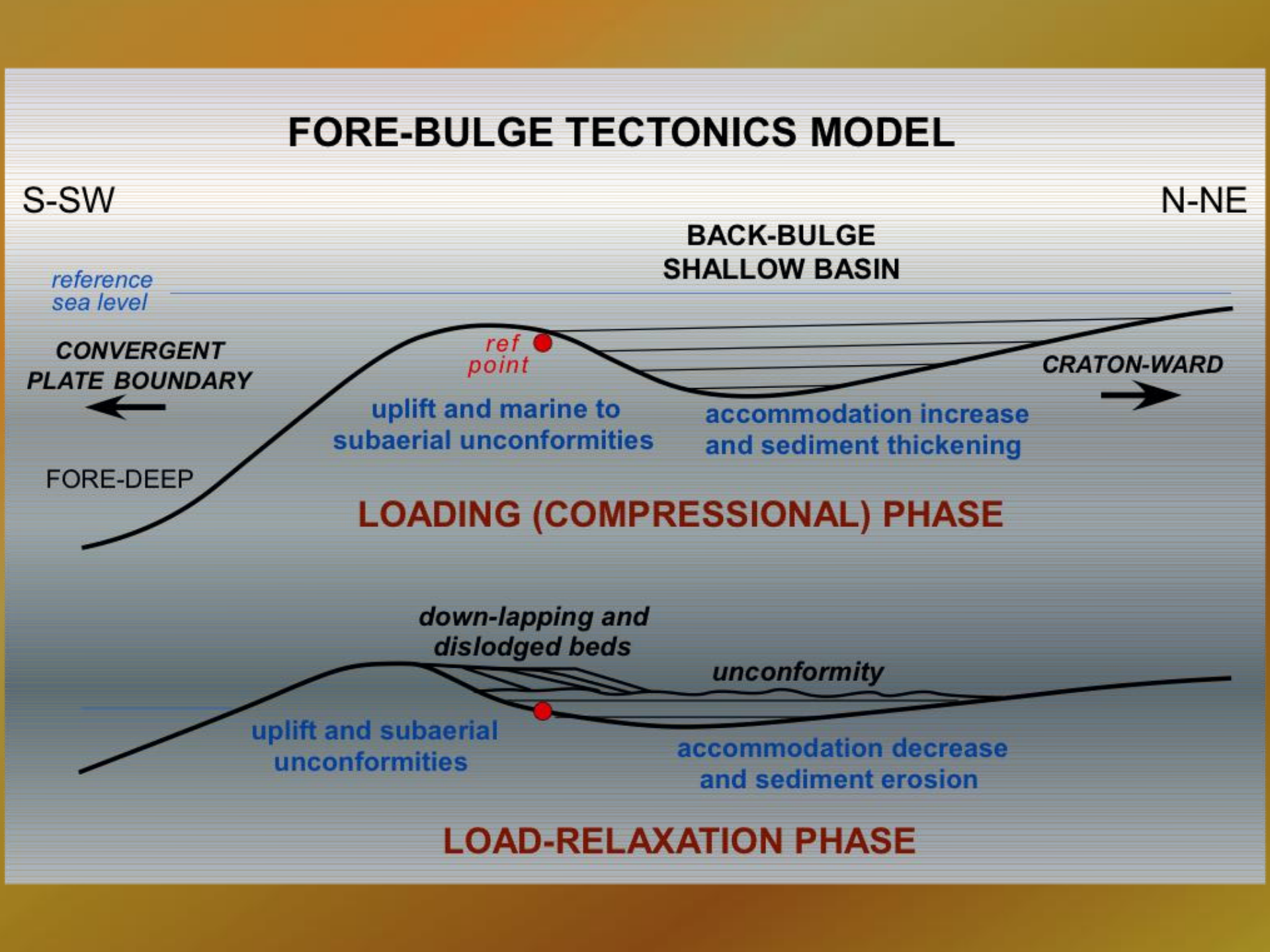
- *oxidized haloes and reddish discoloration along fractures and vugs*
- *clasts of reef matrix floating within vugs*
- *internal vadose crystal silt within vugs and fractures*
- *abundant crinoid overgrowths*

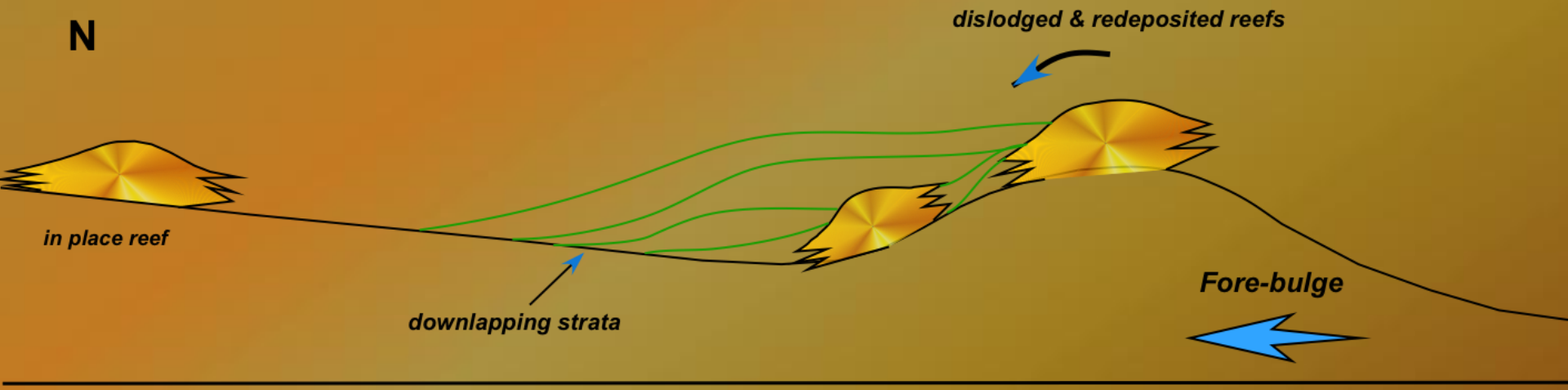
outcrop photo of bryozoan – crinoid bafflestone reefs with abundant meteoric dissolution vugs

Despite the lack of porosity on outcrops these reefs maintain well developed porosity within the subsurface.

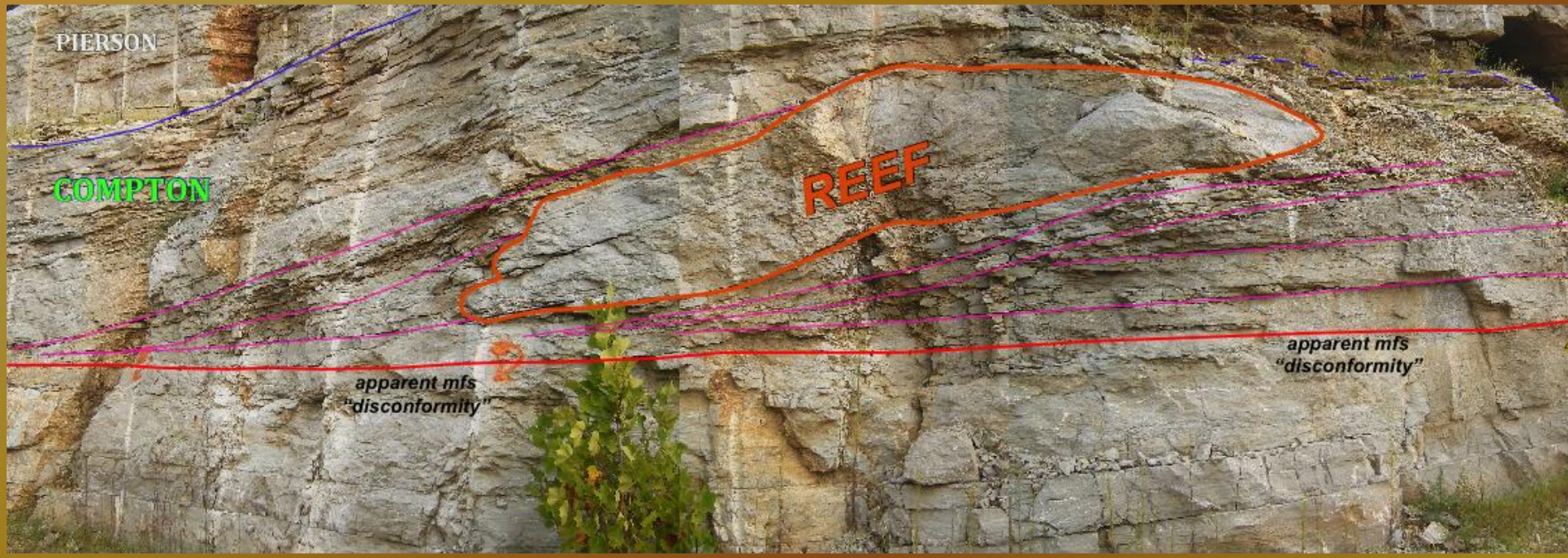


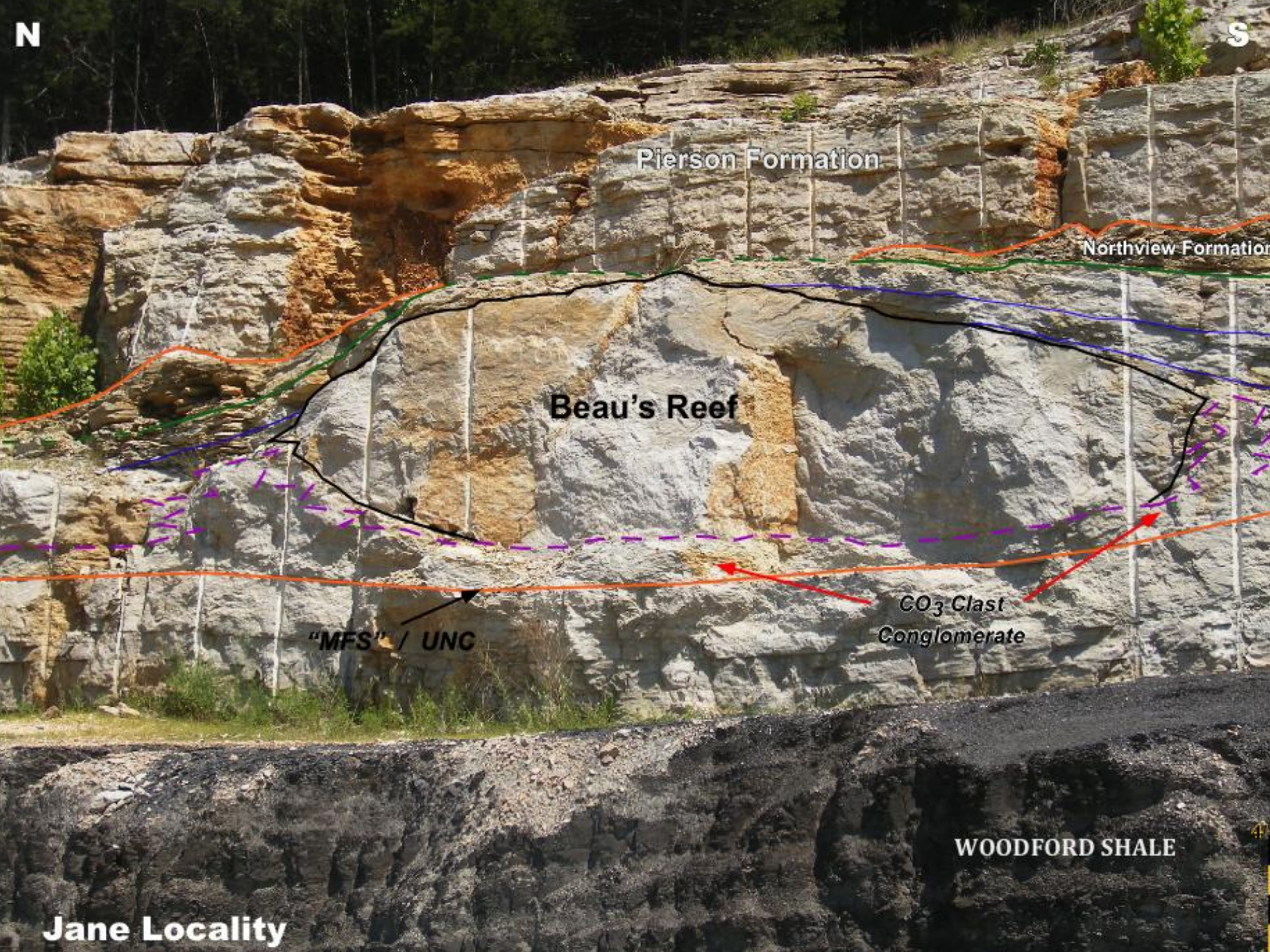
neutron density log from southern Kansas


FORE-BULGE TECTONICS MODEL
S-SW
N-NE
BACK-BULGE
SHALLOW BASIN
reference
sea level
CONVERGENT
PLATE BOUNDARY
ref
point
CRATON-WARD
uplift and marine to
subaerial unconformities
accommodation increase
and sediment thickening
FORE-DEEP
LOADING (COMPRESSIONAL) PHASE
down-lapping and
dislodged beds
unconformity
uplift and subaerial
unconformities
accommodation decrease
and sediment erosion
LOAD-RELAXATION PHASE



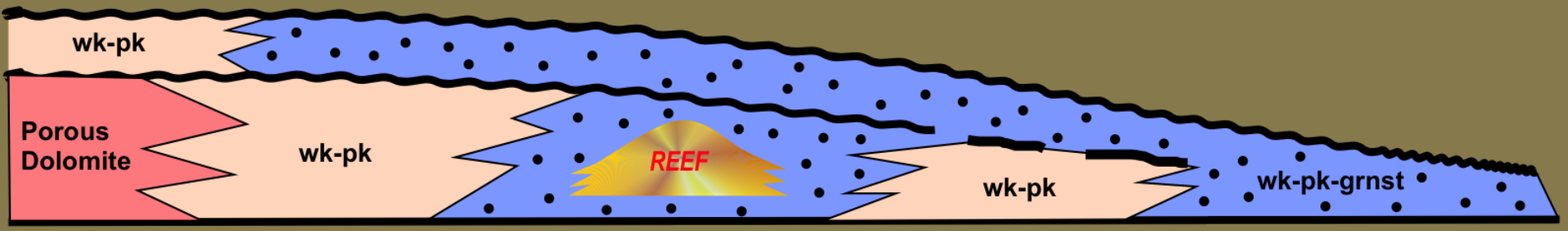
DISLODGED REEFS AND REEF BLOCKS WITHIN THE COMPTON FORMATION




N
S
Pierson Formation
Northview Formation
Beau's Reef
"MFS" / UNC
CO_3 Clast Conglomerate
WOODFORD SHALE
Jane Locality

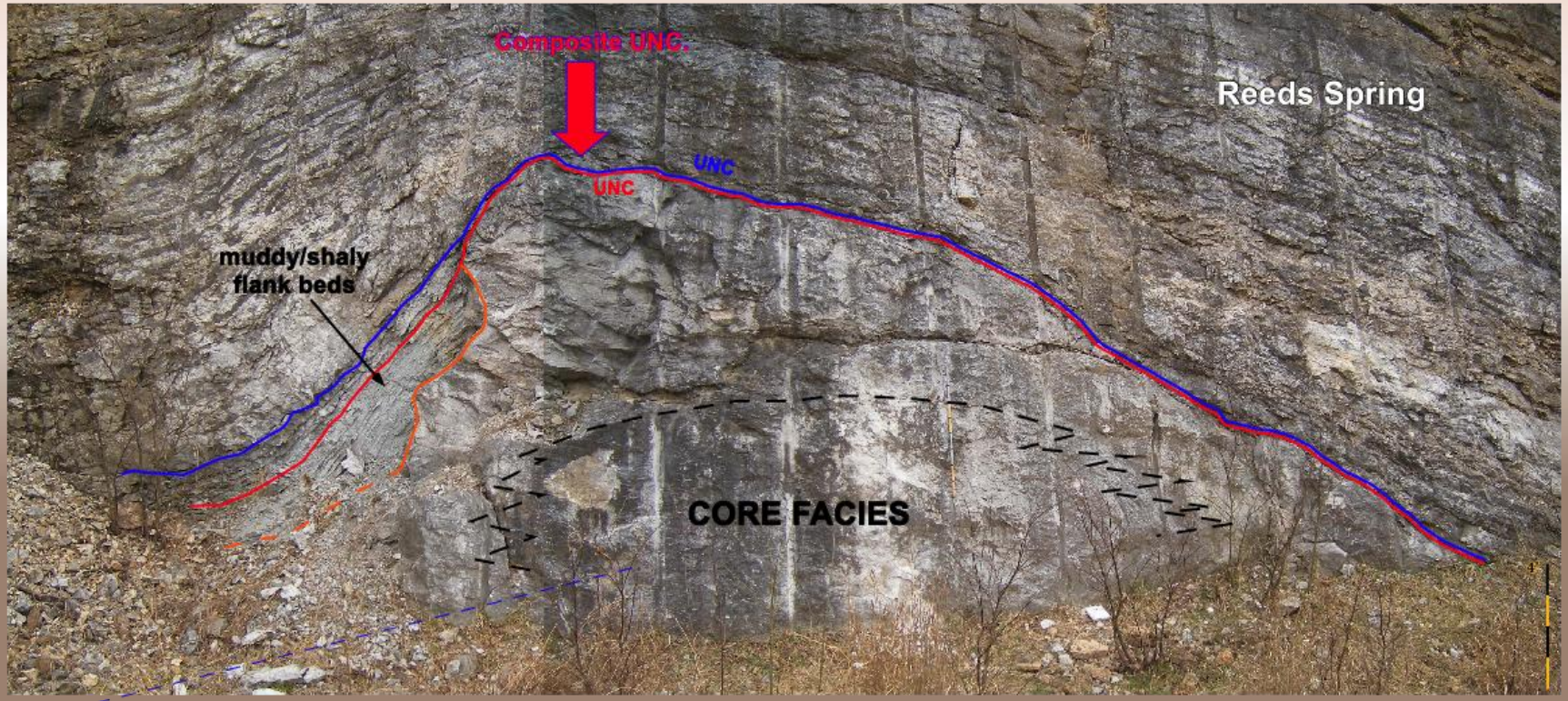
NOEL, MO | HWY. DD LOCALITY, COMPTON FM.

DEPOSITIONAL ARCHITECTURE OF PIERSON REEFS



Mazzullo et. al., 2011

Shallower-water, higher-energy environments than Compton reefs, but again within the medial settings of progradational ramps



Western most Pierson reef with core facies and crestal deposits exposed along Highway 412, E. of Siloam Springs, Arkansas

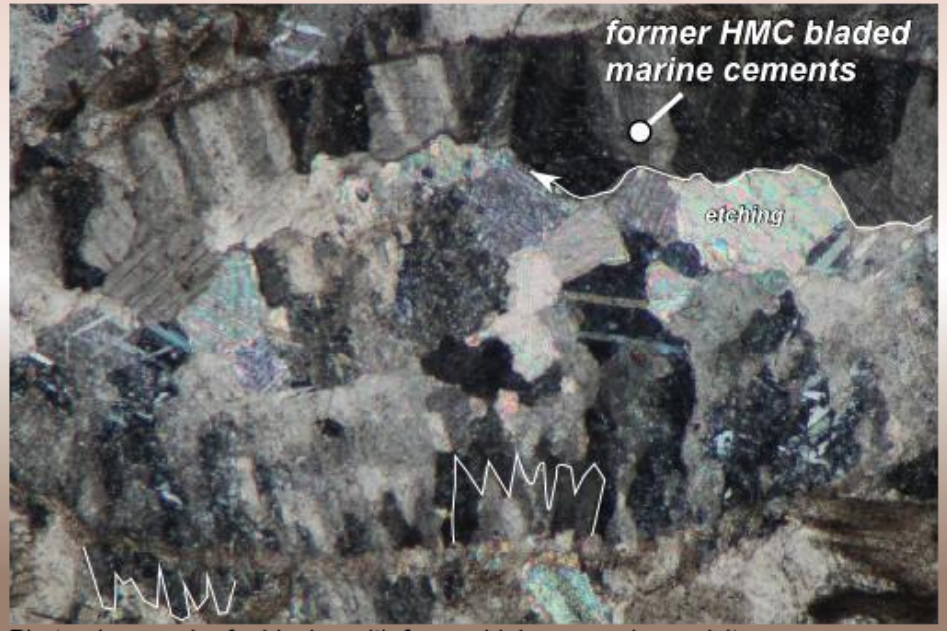
core facies porosity
mostly occluded on outcrop

LAYERED BRYOZOAN-CRINOID BAFFLESTONE REEFS

WITH A PRONOUNCED CORE AND CRESTAL OR CAPPING DEPOSITS

flat bottom convex top shape and up to 16 feet thick on outcrop

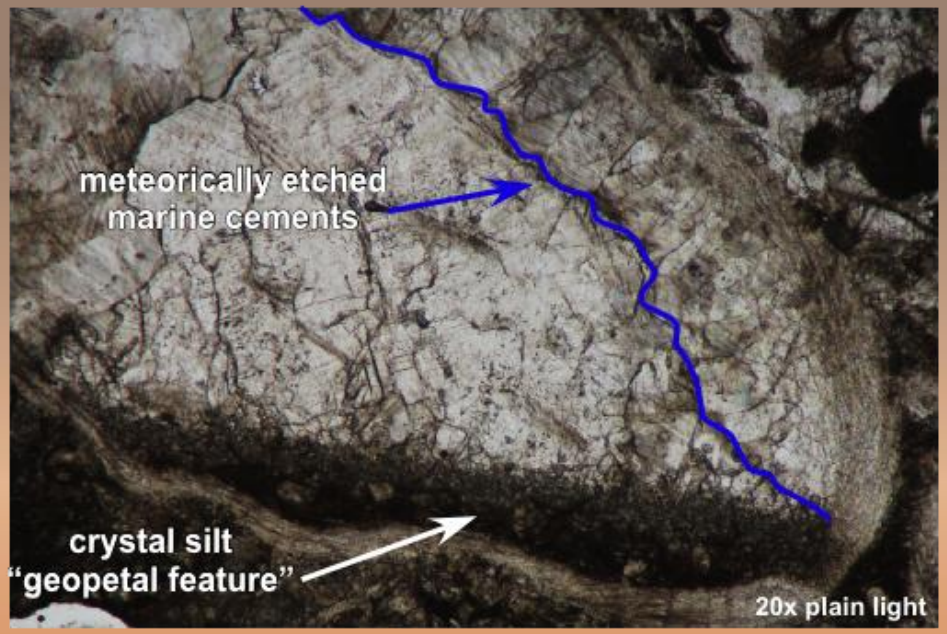
Hand sample photograph of reef core facies (layered bryozoan-crinoid bafflestone), with meteoric dissolution vugs, & marine cements

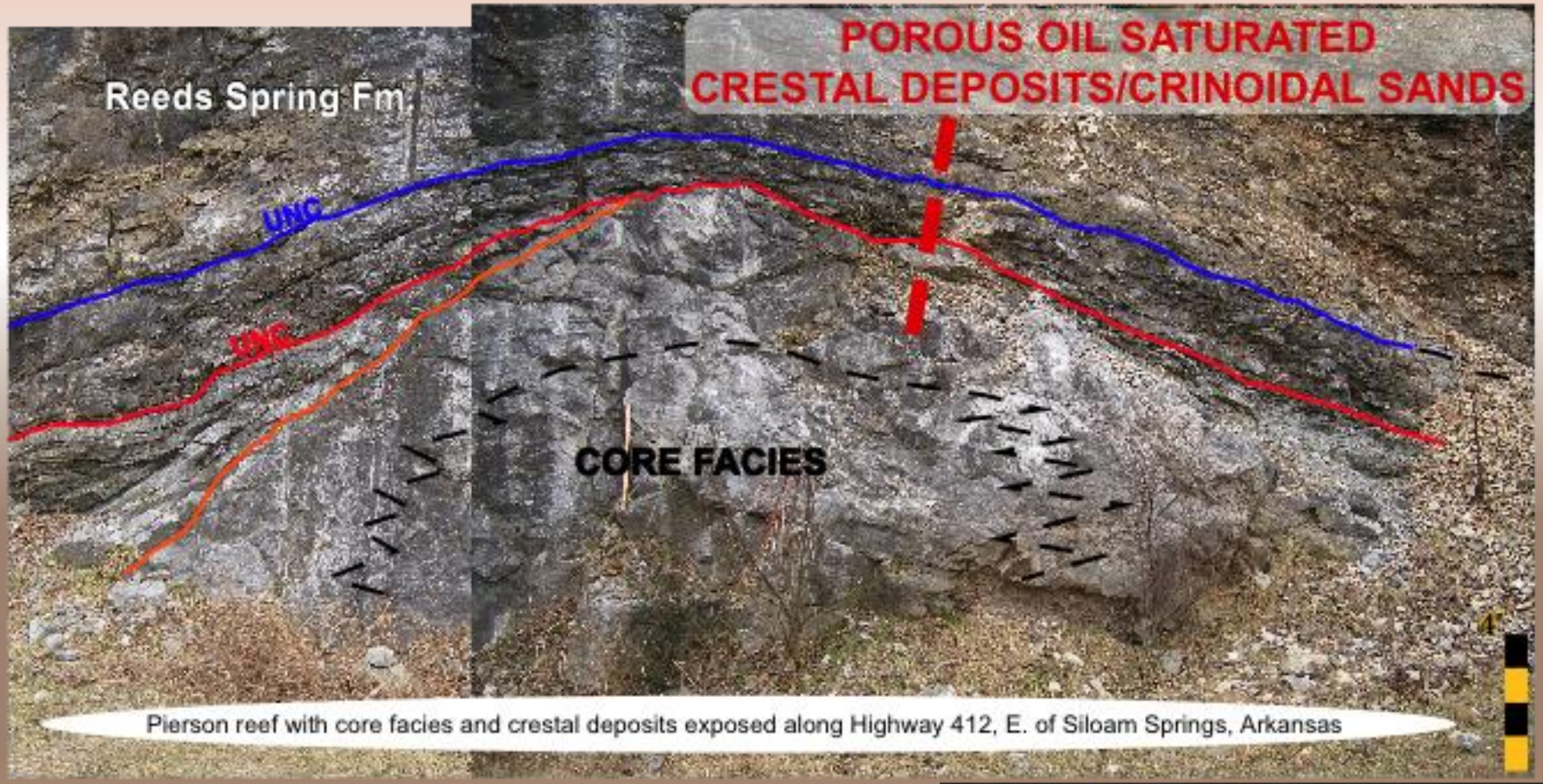


Photomicrograph of a bivalve with former high magnesium calcite bladed marine cements, that have been dissolutionaly etched. 20x magnification, cross polars

Photomicrograph within a vug, isopachous rinds of former high magnesium calcite bladed marine cements rimming bryozoans and later occlusion by coarse pore filling calcite. 20x magnification, plain light

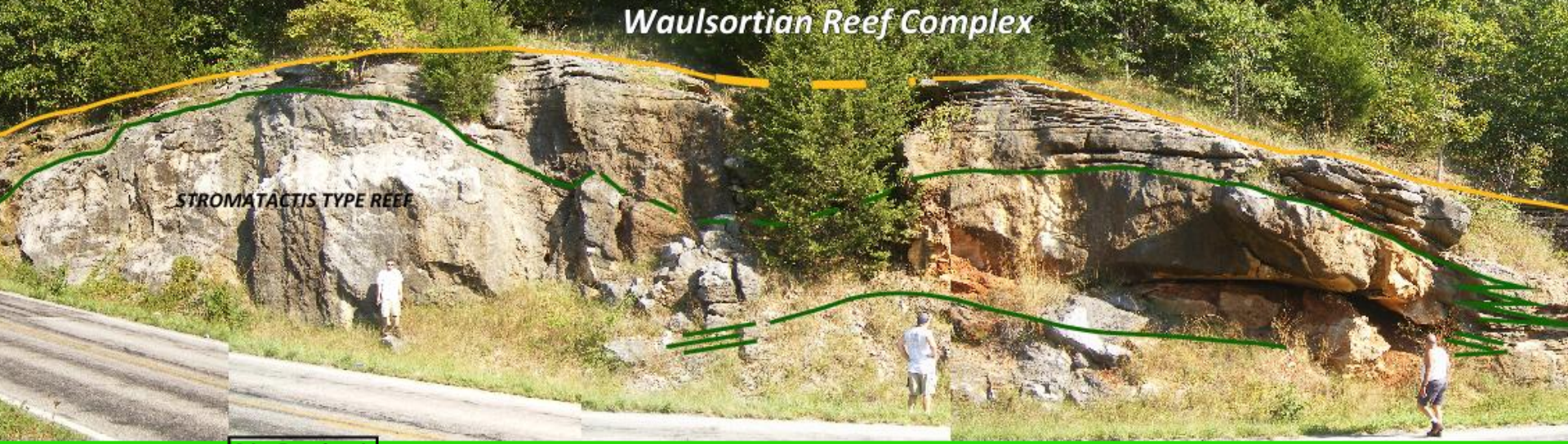
Pierson reefs displaying evidence of unconformity, and similar diagenetic histories.



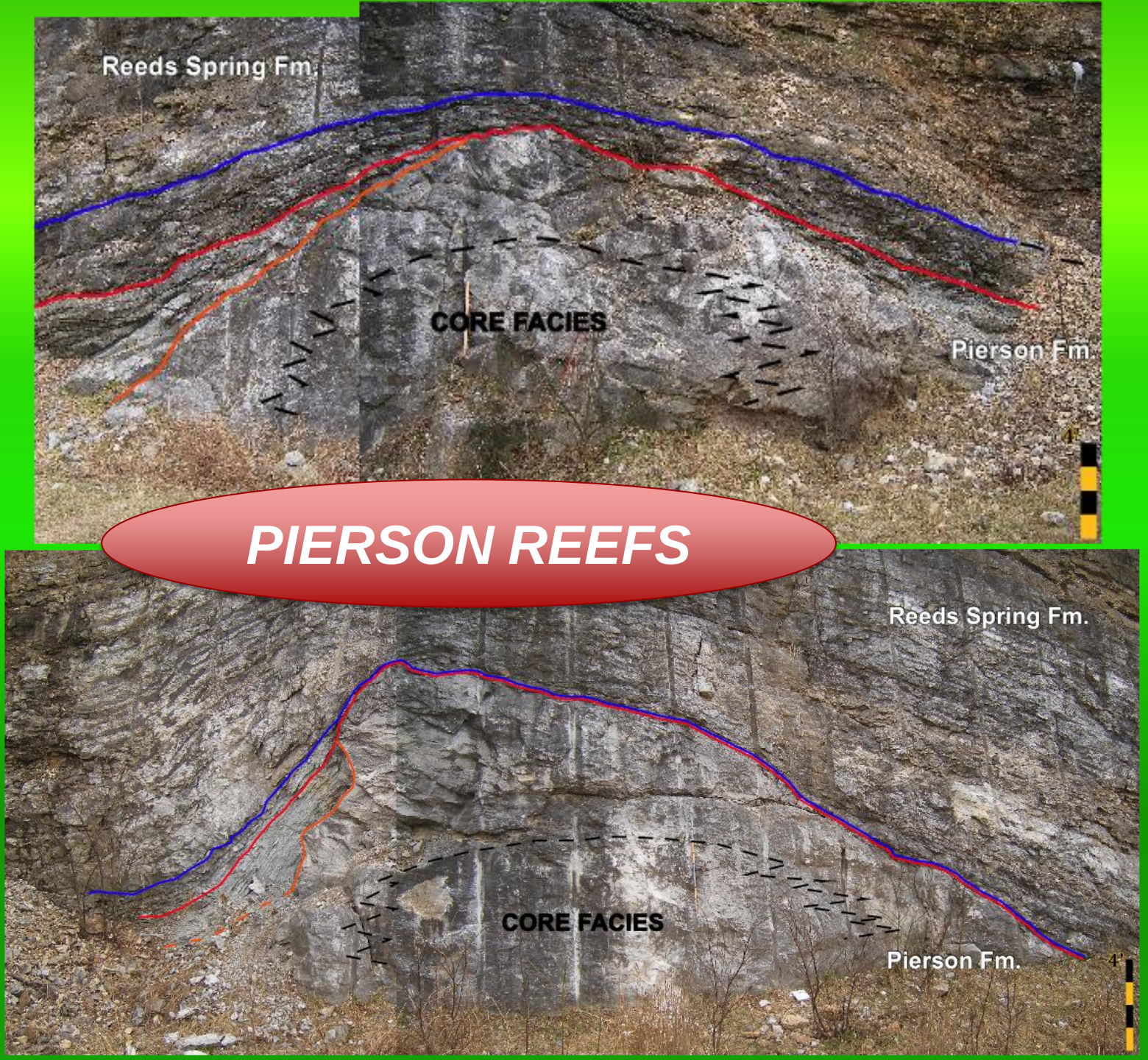


Core facies grade laterally and vertically into less bryozoan rich and more crinoidal rich packstones and grainstones

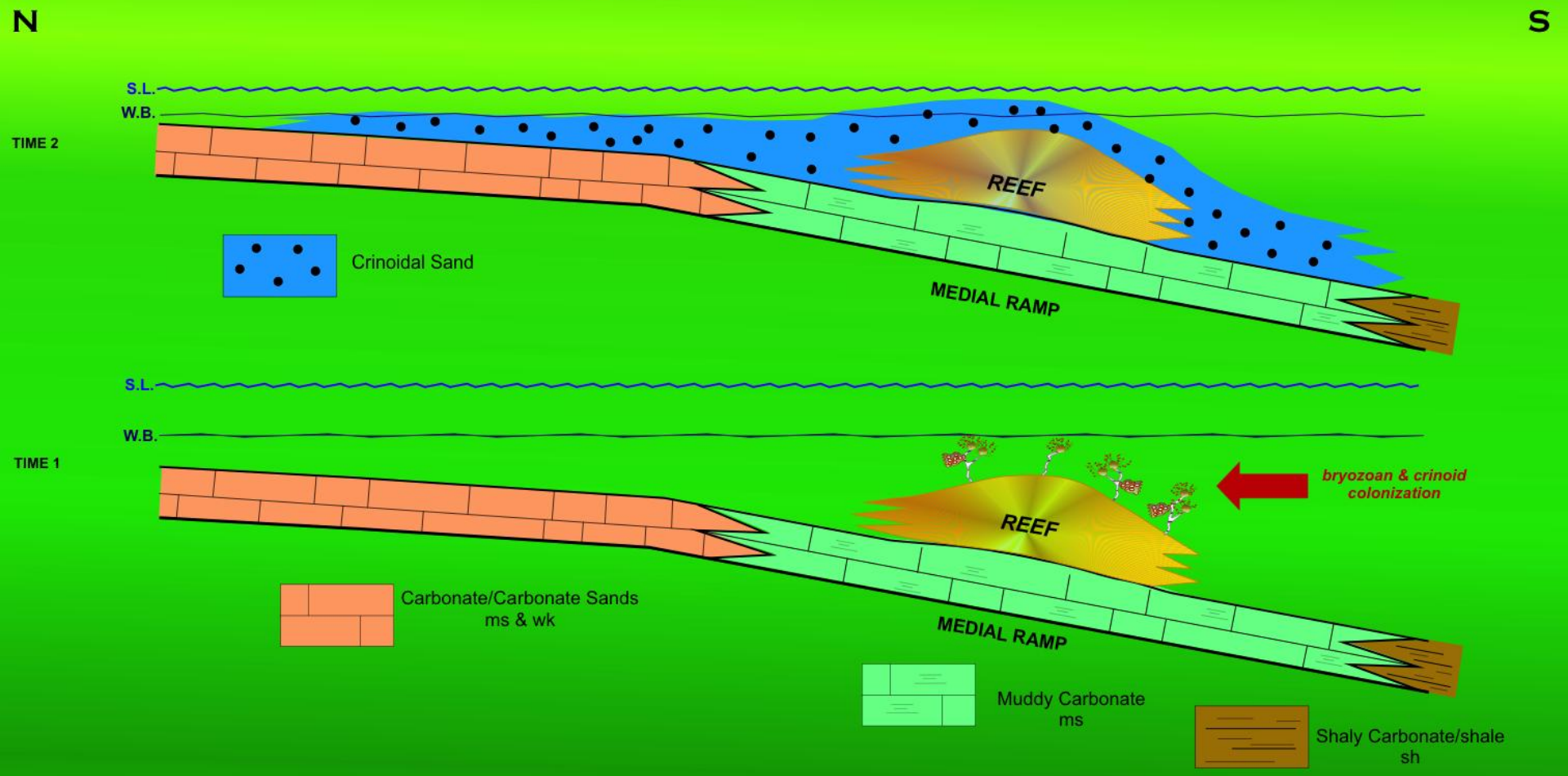
crestal deposits reek of oil on outcrop

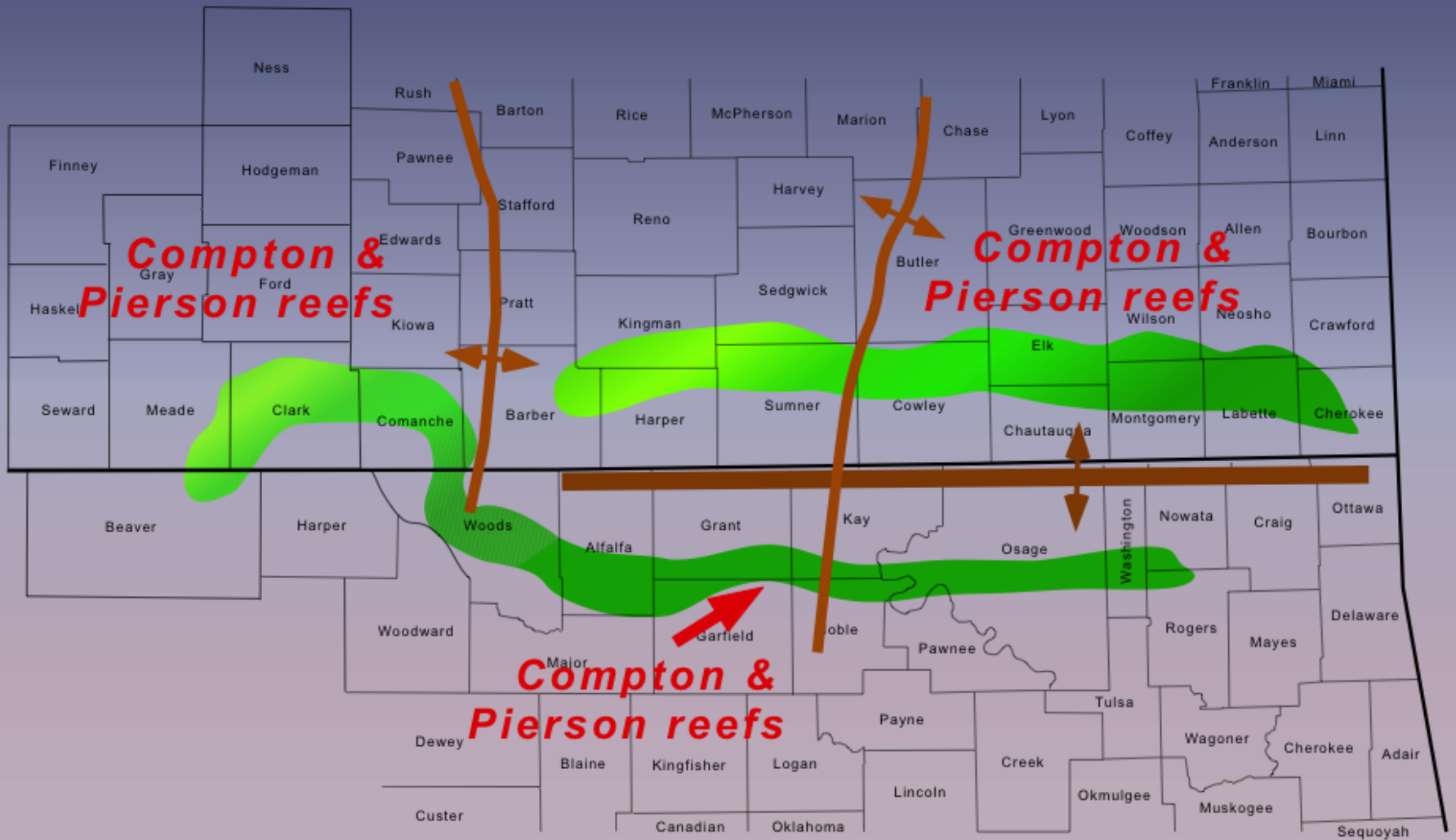


COMPTON REEFS

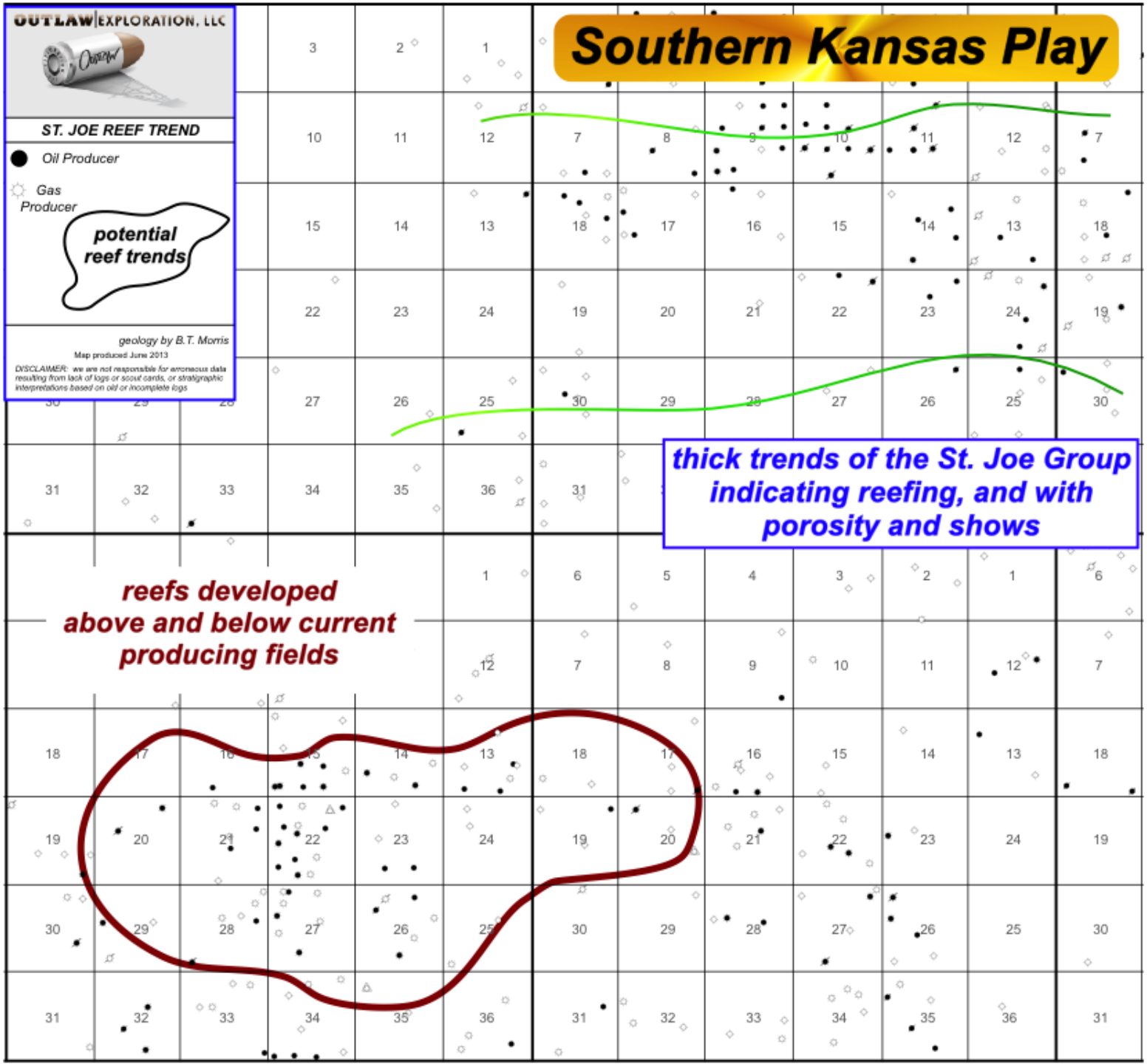

Reeds Spring Fm.
CORE FACIES
Pierson Fm
4'
PIERSON REEFS
Reeds Spring Fm.
CORE FACIES
Pierson Fm.
4'

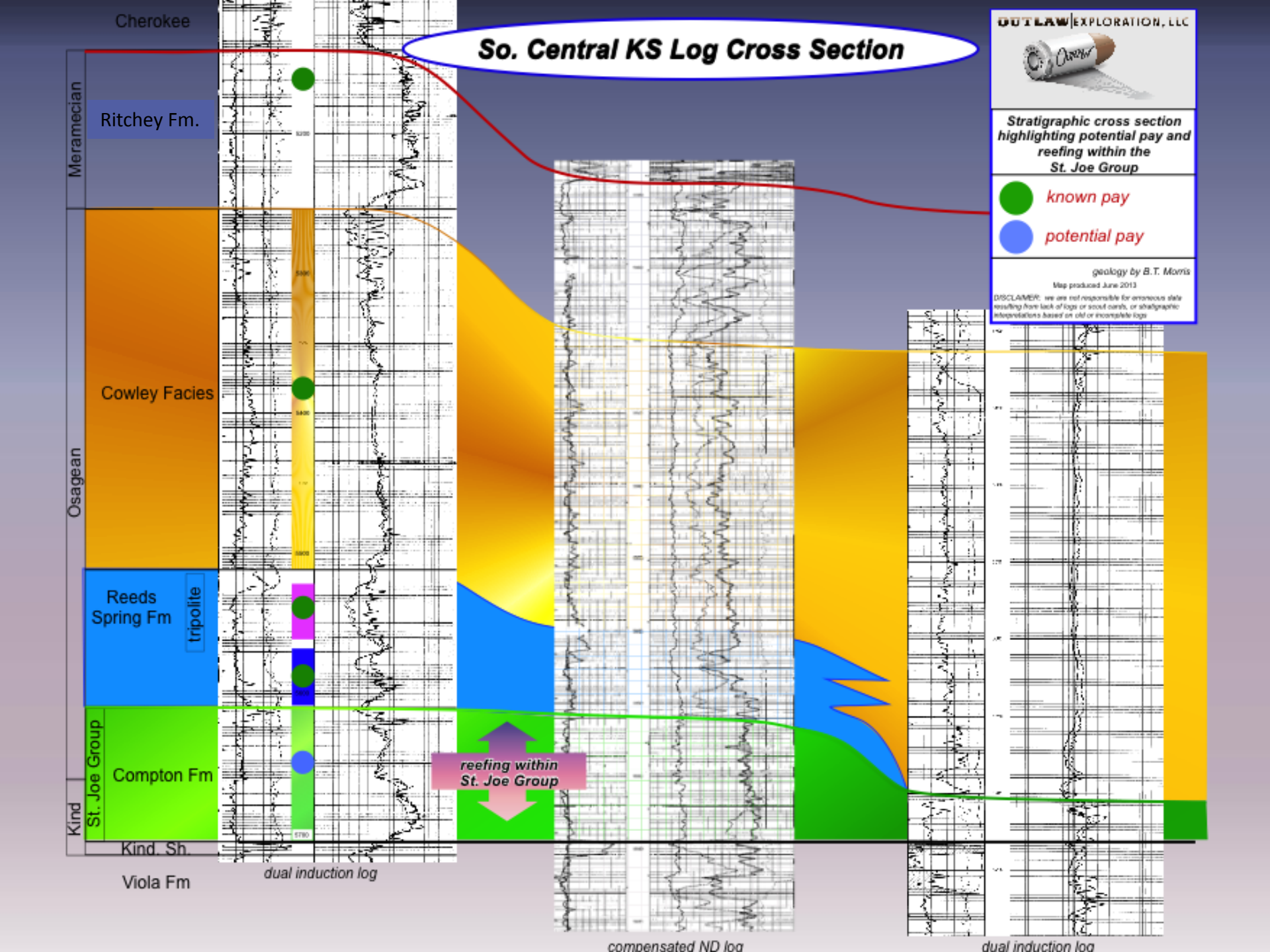
temporal model of reefs on outcrop
as subsurface analogs



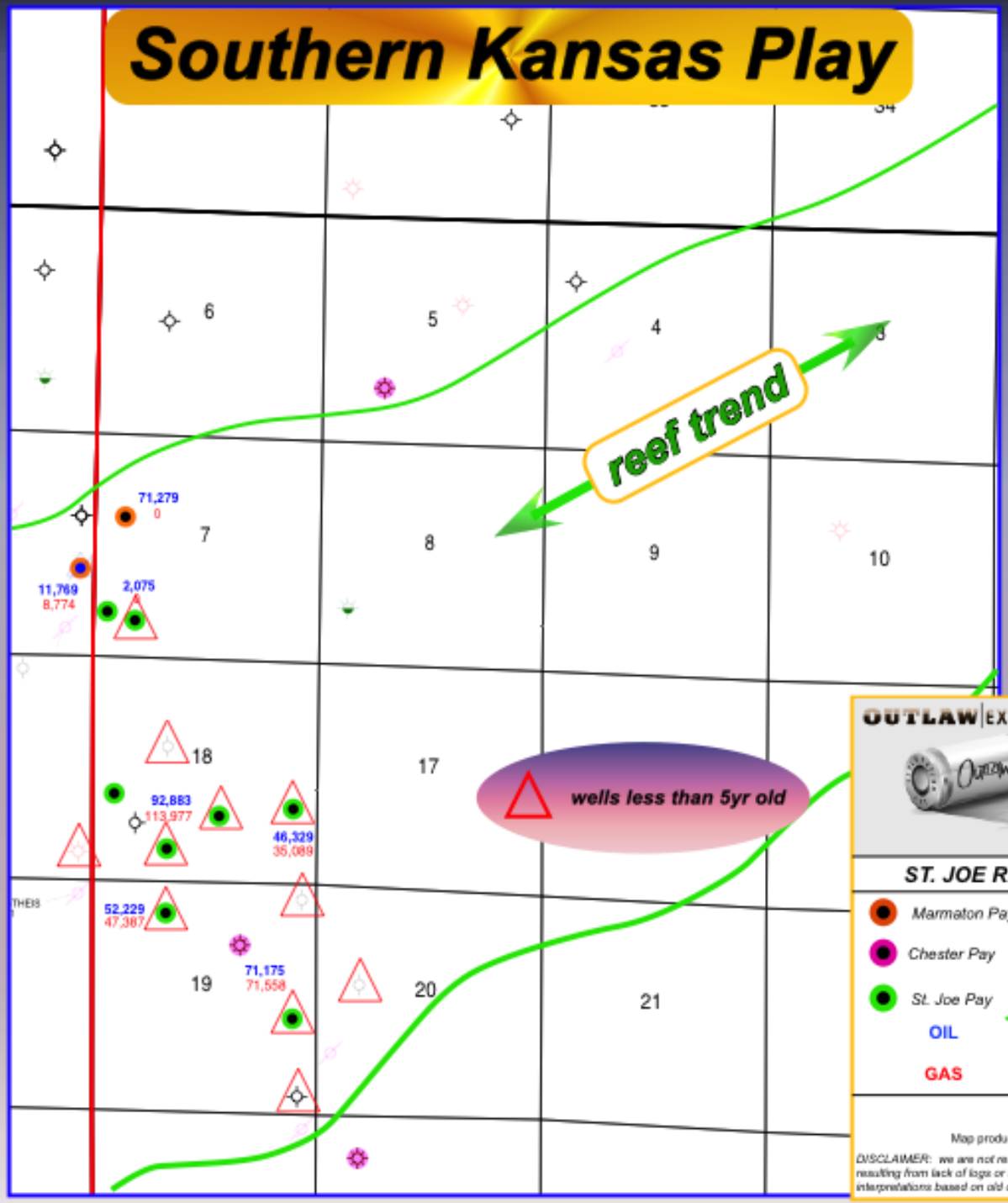


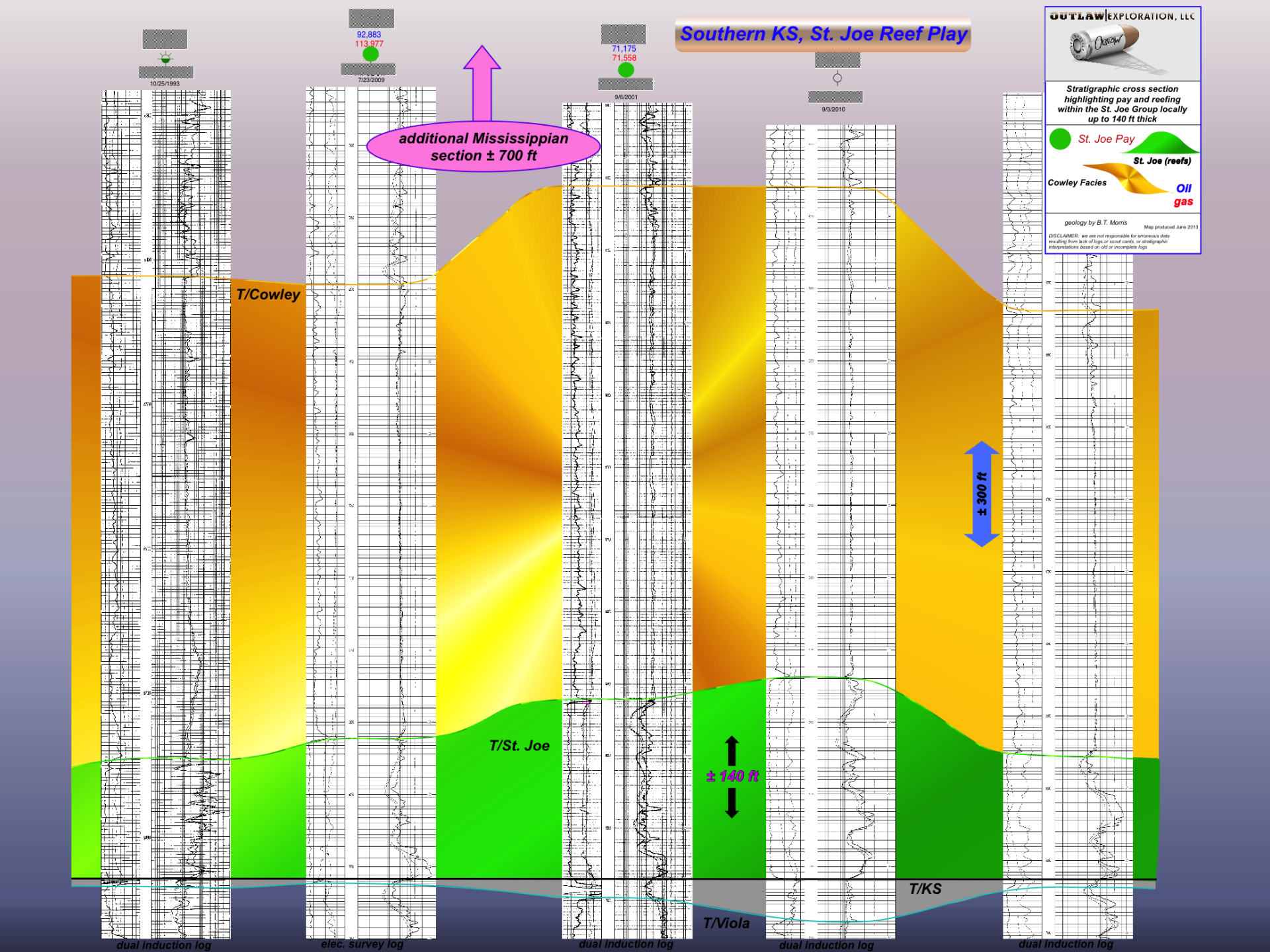
Kansas and Oklahoma county map highlighting areas of potential development.

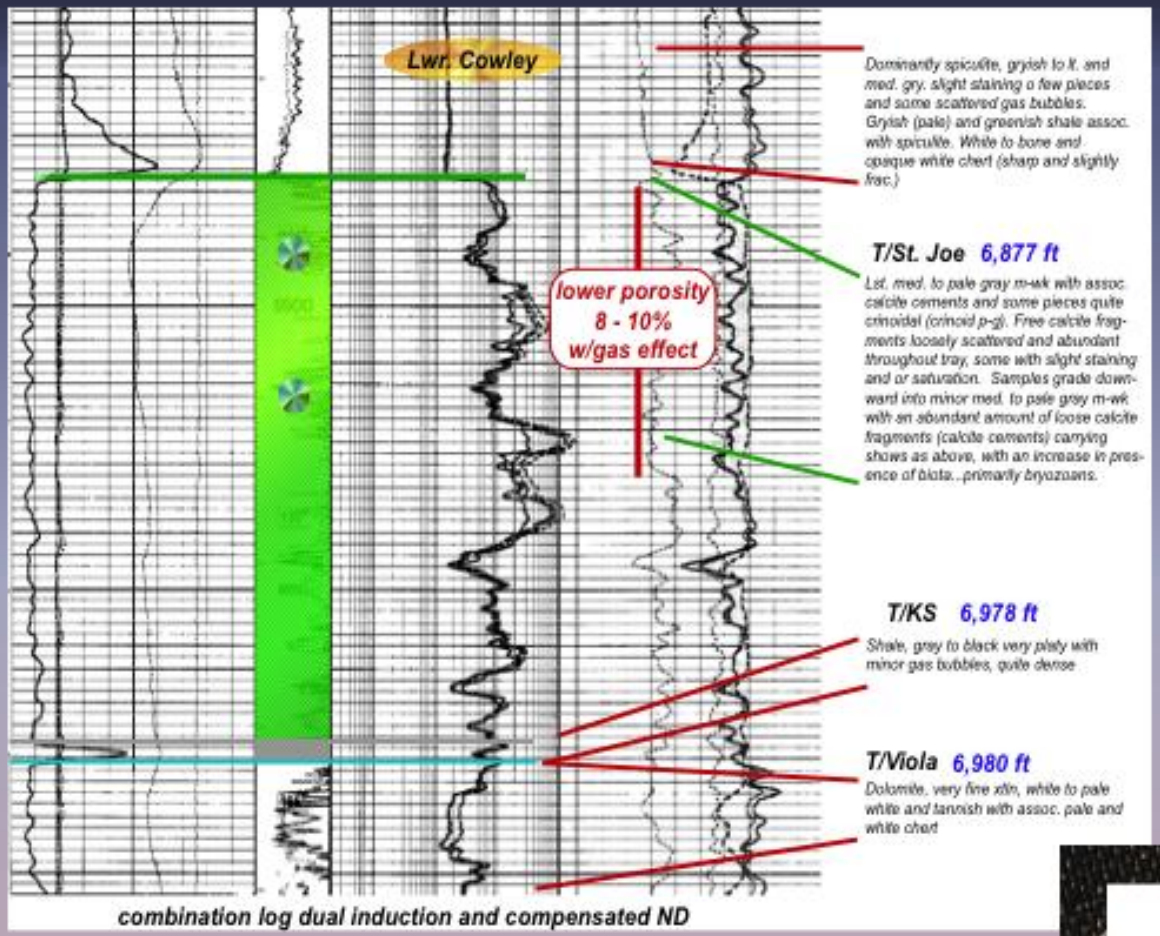

OUTLAW EXPLORATION, LLC
ST. JOE REEF TREND
Oil Producer
Gas Producer
potential reef trends
geology by B.T. Morris
Map produced June 2013
DISCLAIMER: we are not responsible for erroneous data resulting from lack of logs or scout cards, or stratigraphic interpretations based on old or incomplete logs
Southern Kansas Play
thick trends of the St. Joe Group indicating reefing, and with porosity and shows
reefs developed above and below current producing fields


So. Central KS Log Cross Section
OUTLAW EXPLORATION, LLC
Stratigraphic cross section highlighting potential pay and reefing within the St. Joe Group
known pay
potential pay
geology by B.T. Morris
Map produced June 2013
DISCLAIMER: we are not responsible for erroneous data resulting from lack of logs or scout cards, or stratigraphic interpretations based on old or incomplete logs
Cherokee
Meramecian
Ritchey Fm.
Osagean
Cowley Facies
Reeds Spring Fm
tripolite
St. Joe Group
Compton Fm
Kind
Kind. Sh.
Viola Fm
reefing within St. Joe Group
dual induction log
compensated ND log
dual induction log

Southern Kansas Play




Southern KS, St. Joe Reef Play
OUTLAW EXPLORATION, LLC
Stratigraphic cross section highlighting pay and reefing within the St. Joe Group locally up to 140 ft thick
St. Joe Pay
St. Joe (reefs)
Cowley Facies
Oil
gas
geology by B.T. Morris
Map produced June 2013
DISCLAIMER: we are not responsible for erroneous data resulting from lack of logs or scout cards, or stratigraphic interpretations based on old or incomplete logs
10/25/1993
92,883
113,977
7/23/2009
9/6/2001
71,175
71,558
9/3/2010
additional Mississippian section ± 700 ft
T/Cowley
T/St. Joe
T/KS
T/Viola
± 140 ft
± 300 ft
dual induction log
elec. survey log
dual induction log
dual induction log
dual induction log



combination log dual induction and compensated ND

denotes potential pay

Representative log and core sample from two potential southern KS reef plays highlighting examined cuttings across the St. Joe Group interval

Compton Formation, reef hand sample and its associated rock chips representing a nearly identical match to well cuttings examined across wellbores in southern Kansas

core sample from southern KS and its corresponding well cuttings