

Tripolitic Chert Development in the Mississippian Lime: New Insights from SEM*

Walter L. Manger¹

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Abstract

The Lower Mississippian succession in the southern midcontinent is an unconformity-bounded, third order, eustatic cycle with superimposed fourth and fifth order cycles.

Lithostratigraphically, in Missouri/Oklahoma and Arkansas, the TST is referred to the Bachelor, Compton, Northview and Pierson Formations = St. Joe Limestone; the MFI is referred to the Reeds Spring Formation = Lower Boone Formation; and the HST/RST is referred to the Elsey, Burlington-Keokuk Formations = Upper Boone Formation. The MFI is characterized by penecontemporaneous chert - black to dark gray, compaction phenomena/disruption of bedding, shrinkage fractures, lack of included macrofossils, low carbonate content. The HST/RST is characterized by later diagenetic chert – white to cream, obvious silicification fronts and replacement along limestone bedding planes, replication of original textures, favors finer grained lithologies, commonly fossiliferous, high carbonate content - youngest portions of RST lack chert. Late diagenetic chert is a groundwater phenomenon and was already in place by the beginning of the Chesterian deposition.

Tripolitic chert forms by decalcification – removal by groundwater solution of carbonate grains, mostly bioclastic, included within the chert. There is not a high enough percentage of carbonate in typical Reeds Spring penecontemporaneous chert to produce tripolitic chert. In the Lower Mississippian succession of the southern midcontinent, the only chert that contains enough carbonate to be leached and form tripolitic chert occurs in the Elsey, Burlington-Keokuk Formations = Upper Boone Formation. In the Ouachita region, tripolitic chert development in the Arkansas Novaculite is restricted to its upper division, which also turns out to be calcareous.

The tripolitic chert interval experienced a second invasion by silica-bearing, hydrothermal water that allowed euhedral, quartz crystal druse to form in voids produced by the earlier decalcification. This water is probably the same medium that deposited the lead and zinc in the tri-state region suggesting that tripolitic chert formation is not older than Paleozoic age.

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TRIPOLITIC CHERT DEVELOPMENT IN THE MISSISSIPPIAN LIME: NEW INSIGHTS FROM SEM

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University of Arkansas



OKLAHOMA CITY, OKLAHOMA
February 20, 2014

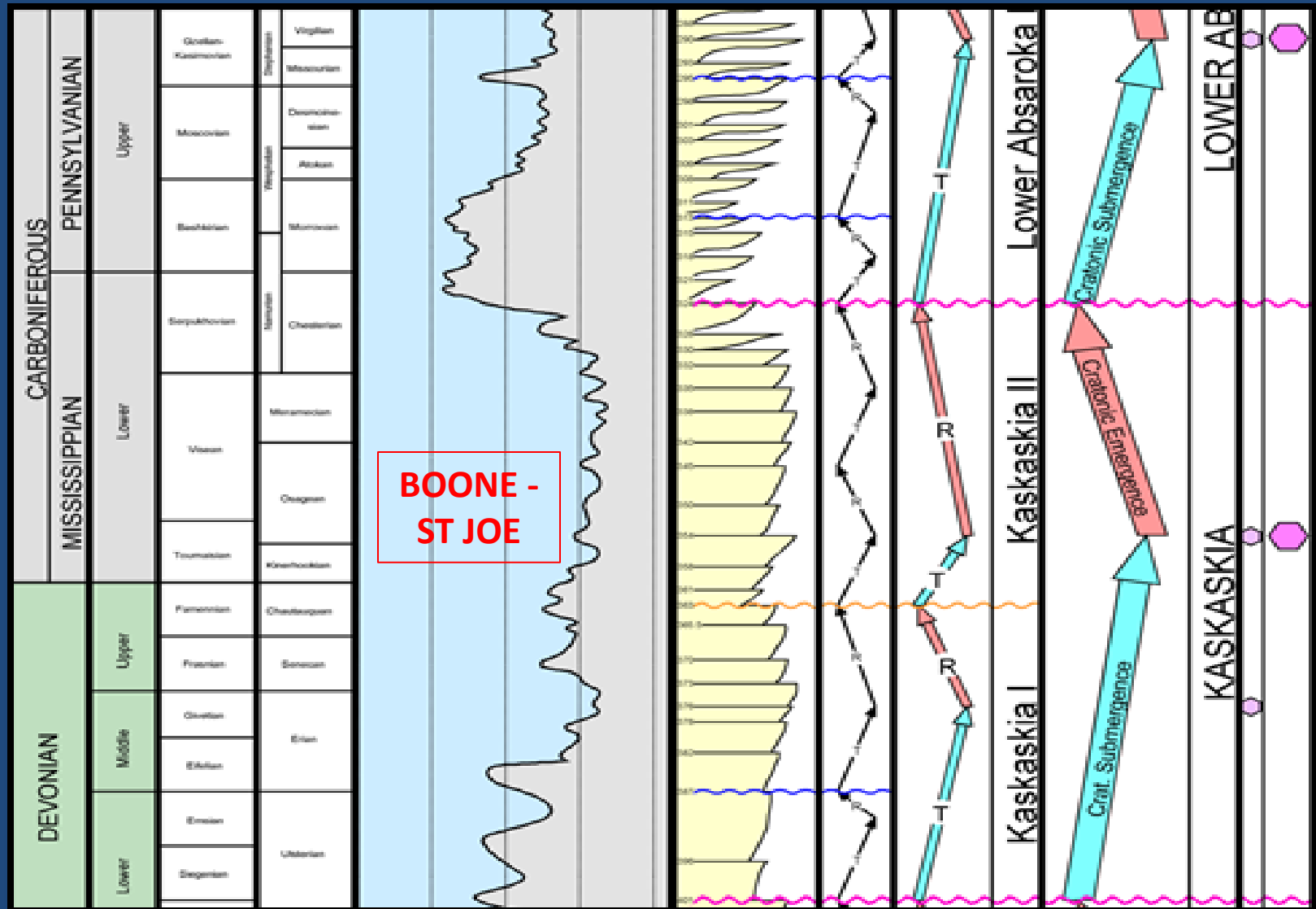
SIGNIFICANT OBSERVATIONS ON THE GEOLOGIC SETTING OF TRIPOLITIC CHERT DEVELOPMENT IN THE LOWER MISSISSIPPIAN SUCCESSION, SOUTHERN MIDCONTINENT

- ▶ The Lower Mississippian succession in the southern midcontinent is an unconformity-bounded, third order, eustatic cycle with superimposed fourth and fifth order cycles
- ▶ Lithostratigraphically, in Missouri/Oklahoma and Arkansas, the TST is condensed and referred to the St. Joe Limestone = Bachelor, Compton, Northview and Pierson Formations; the MFI is referred to the Reeds Spring Formation = Lower Boone Formation; the HST/RST is referred to the Elsey, Burlington-Keokuk Formations = Upper Boone Formation. Chronostratigraphically, the Kinderhookian-Osagean boundary is at the Northview-Pierson contact, or within the first foot of the Pierson
- ▶ The MFI is characterized by penecontemporaneous chert - black to dark gray, vitreous luster, compaction phenomena/disruption of bedding, shrinkage fractures, lack of macrofossils, low carbonate content

SIGNIFICANT OBSERVATIONS ON THE GEOLOGIC SETTING OF TRIPOLITIC CHERT DEVELOPMENT IN THE LOWER MISSISSIPPIAN SUCCESSION, SOUTHERN MIDCONTINENT, cont.

- ▶ The HST/RST is characterized by later diagenetic chert – white to cream, obvious silicification fronts and replacement along limestone bedding planes, replication of original textures, favors finer grained lithologies, commonly fossiliferous, high carbonate content - youngest portions of RST lack chert
- ▶ In outcrop, there is a transitional zone between the black, penecontemporaneous , and white, later diagenetic chert, characterized by white, nodular chert that likely represents the Elsey Formation as recognized in Missouri lithostratigraphy
- ▶ Late diagenetic chert was already in place by the beginning of the Chesterian Series

CORRELATION OF ORDERS OF CARBONIFEROUS EUSTATIC CYCLICITY (WAITE, 2000 from various sources)



O-M BOUNDARY ▶

5 ZONES, 4 SUBZONES

REGRESSION

OSAGEAN SERIES

BURLINGTON-KEOKUK LIMESTONE

KINDERHOOK SERIES

Northview FM.

Compton Limestone

Achelorr FM.

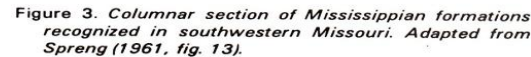
Chattanooga Shale

Sylamore ss.

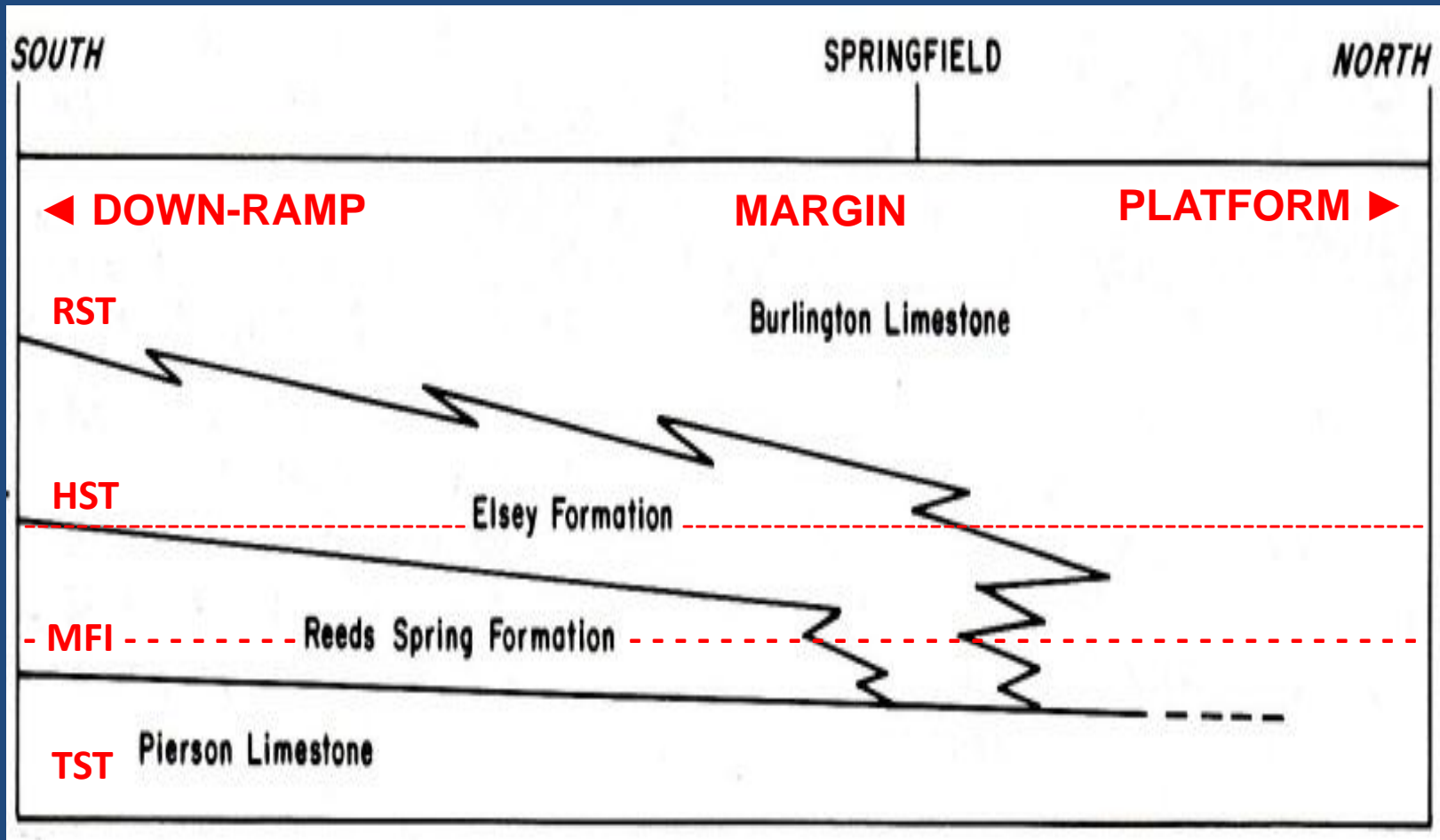
Unc

DEV.

K-O BOUNDARY < 30 FT - 4 Z, 4 SZ BASE MISSISSIPPIAN

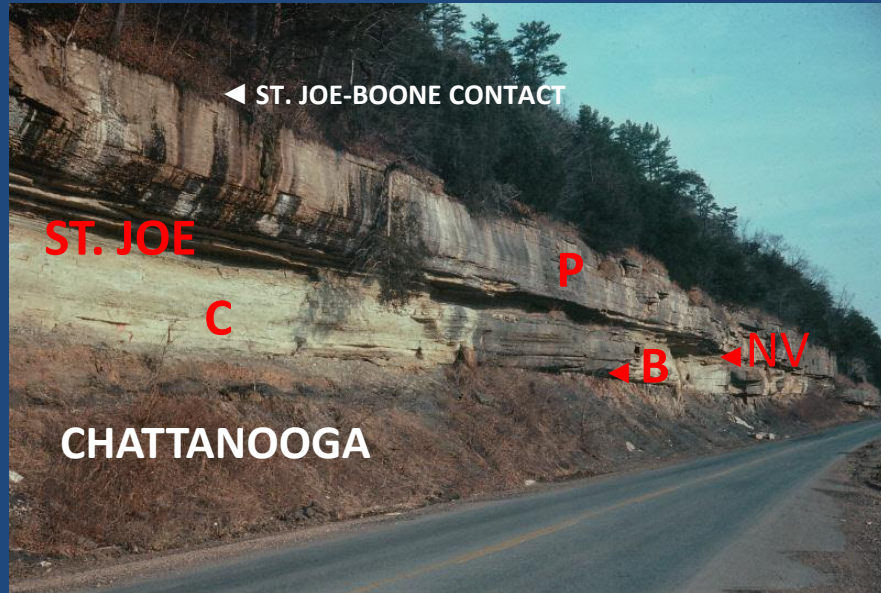


NORTH-SOUTH FACIES RELATIONSHIPS, OSAGEAN SERIES – MISSOURI PLATFORM AND OZARK RAMP



Thompson, 1986, WITH ADDITIONS

LOWER MISSISSIPPIAN OUTCROP, NORTHWESTERN ARKANSAS AND SOUTHWESTERN MISSOURI

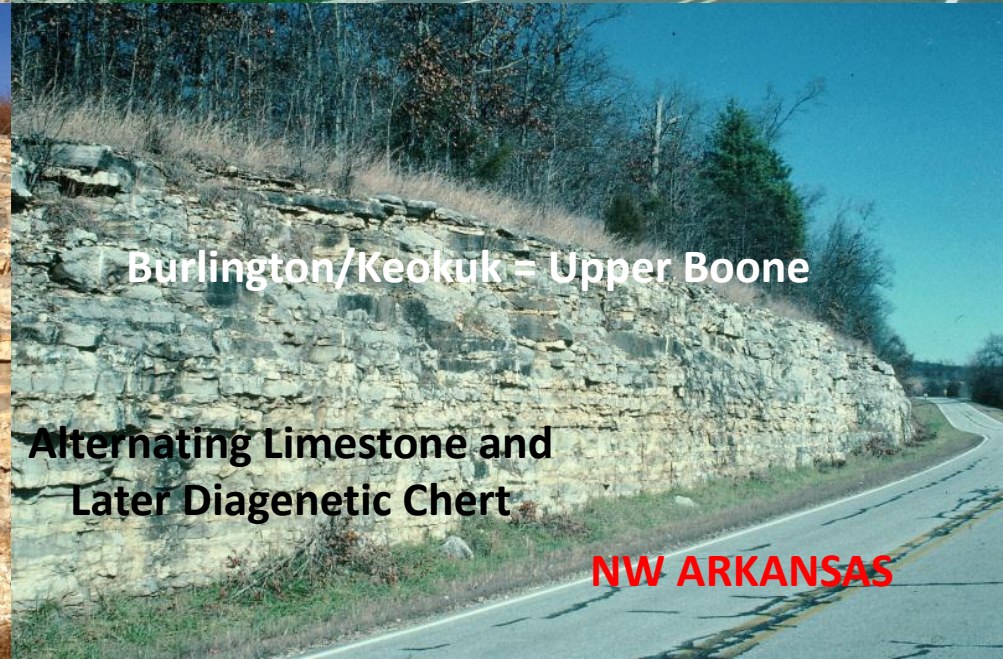
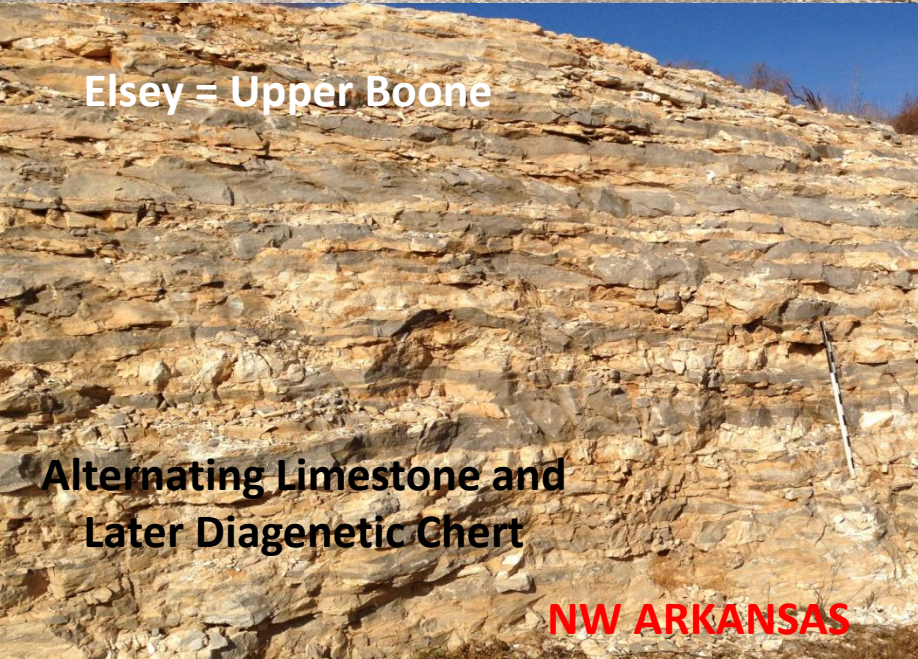


TRANSGRESSION TO
MAXIMUM FLOODING
INTERVAL = ST JOE TO LOWER
BOONE = REEDS SPRING

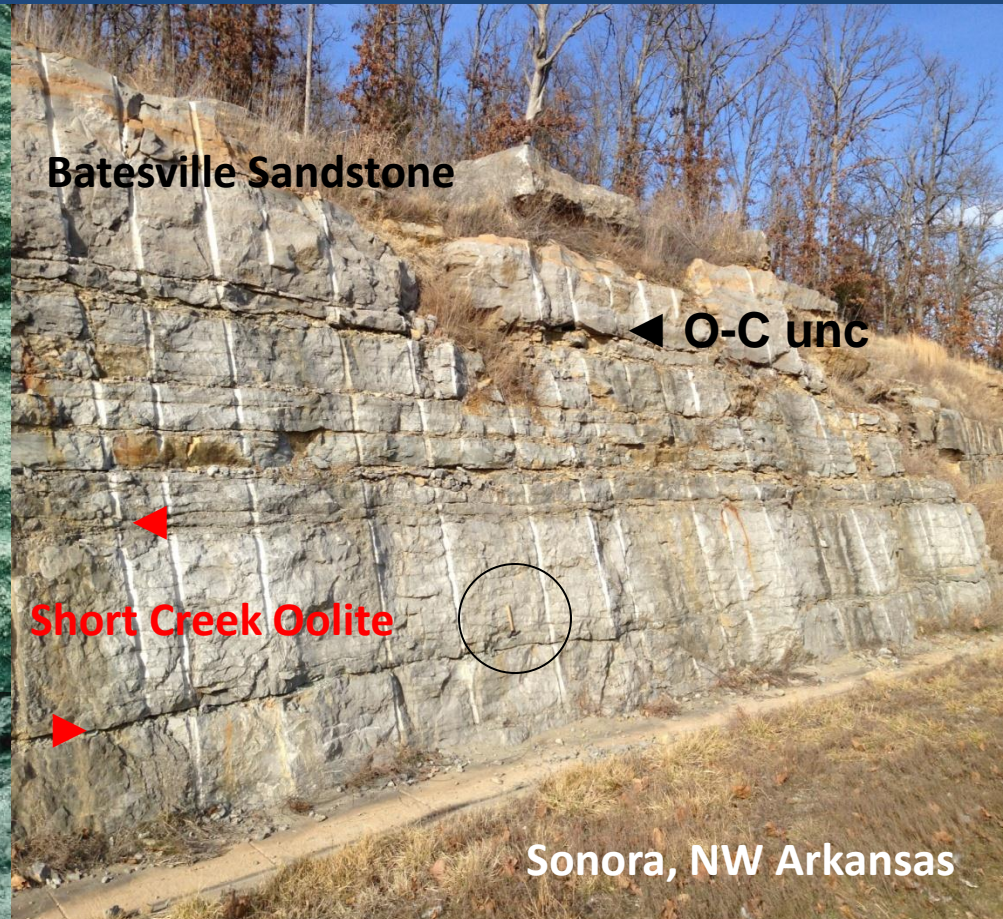


Transported limestones – become mud-
dominated up-section

LOWER MISSISSIPPIAN OUTCROPS - MISSOURI AND ARKANSAS — MAXIMUM FLOODING-HIGHSTAND-REGRESSION



BURLINGTON/KEOKUK – REGRESSIVE SEQUENCE



Return to Effective Wave Base

**Mobile Skeletal Sand of Crinozoan Detritus and
Bedded Oolite deposited by Grain-flow**

NOTE LACK OF CHERT

Springfield, SW Missouri

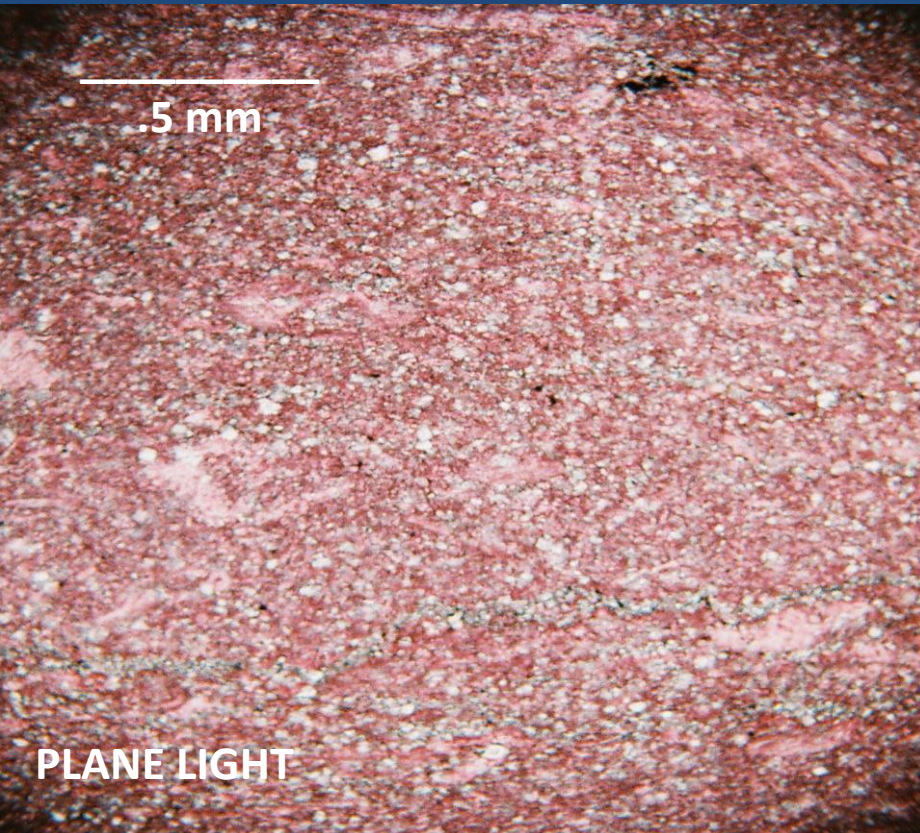
PENECONTEMPORANEOUS CHERT – LOWER BOONE – MAXIMUM FLOODING INTERVAL



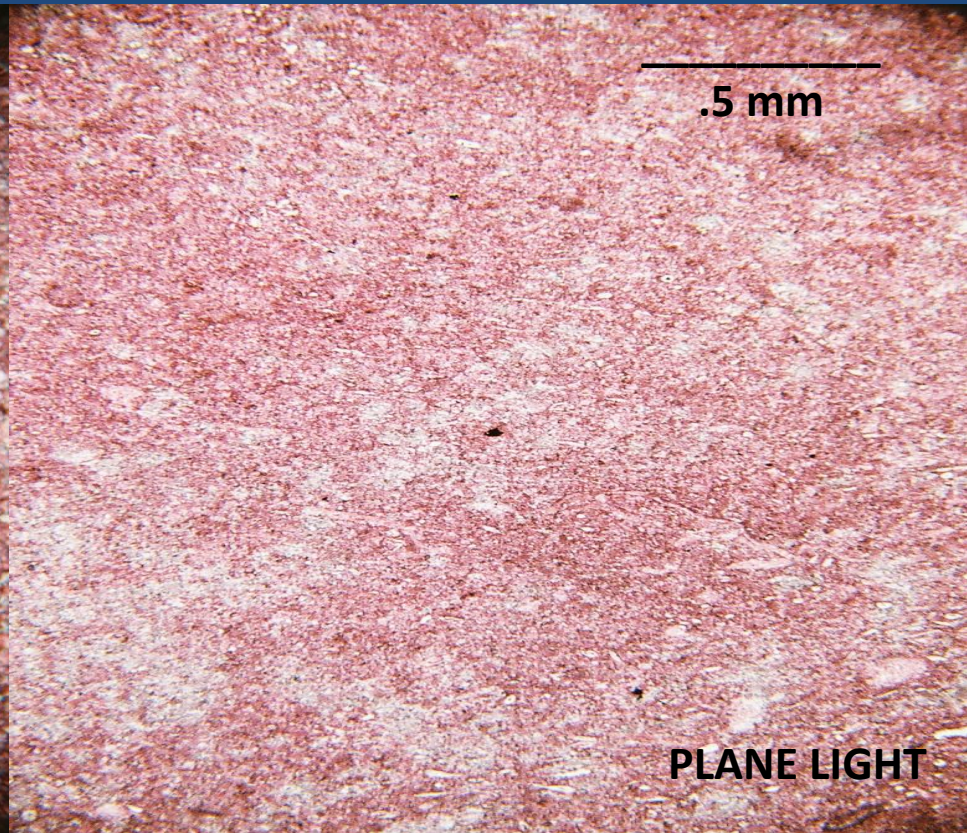
112 miles southeast of Bella Vista, AR
56 miles down-ramp

Roadcut, Vendor, Arkansas

CARBONATE TEXTURAL SPECTRUM - LOWER BOONE = REEDS SPRING INTERVAL



**FINE-VERY FINE GRAINED
DOLOMITIC, BIOCLASTIC
PACKSTONE**



**DOLOMITIC, BIOCLASTIC
CALCISILTITE**

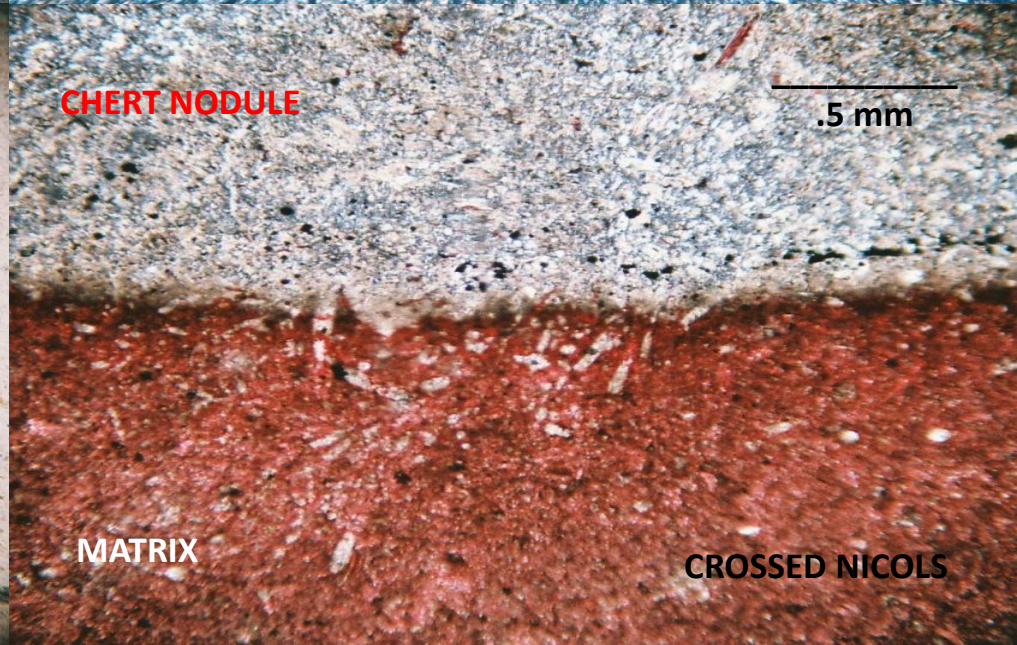
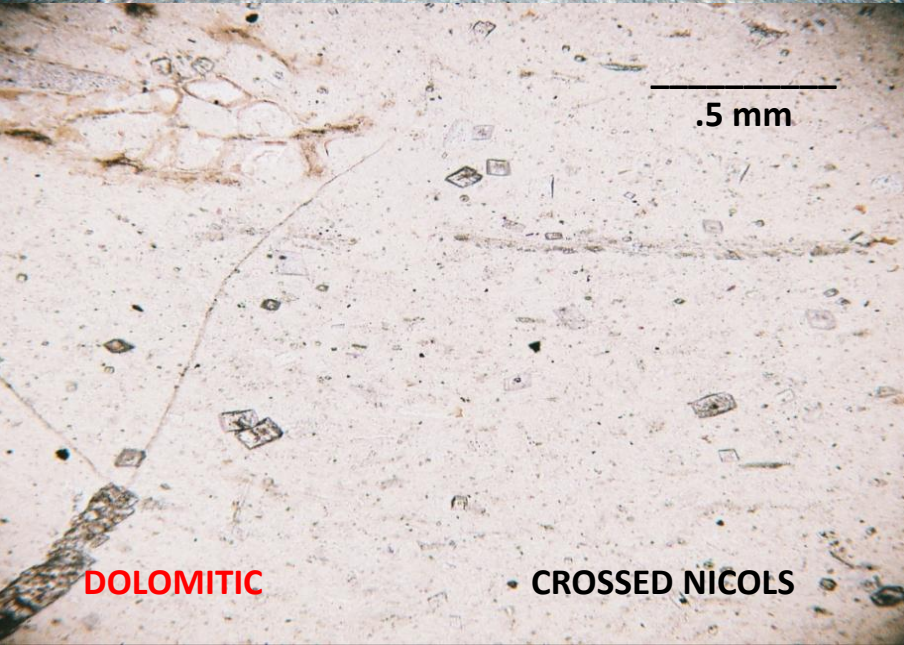
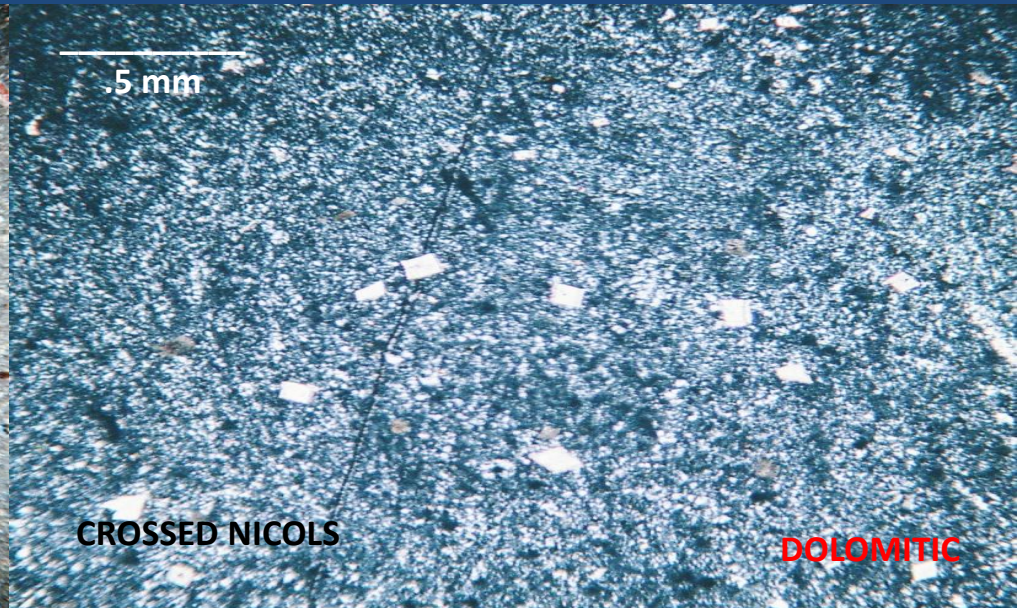
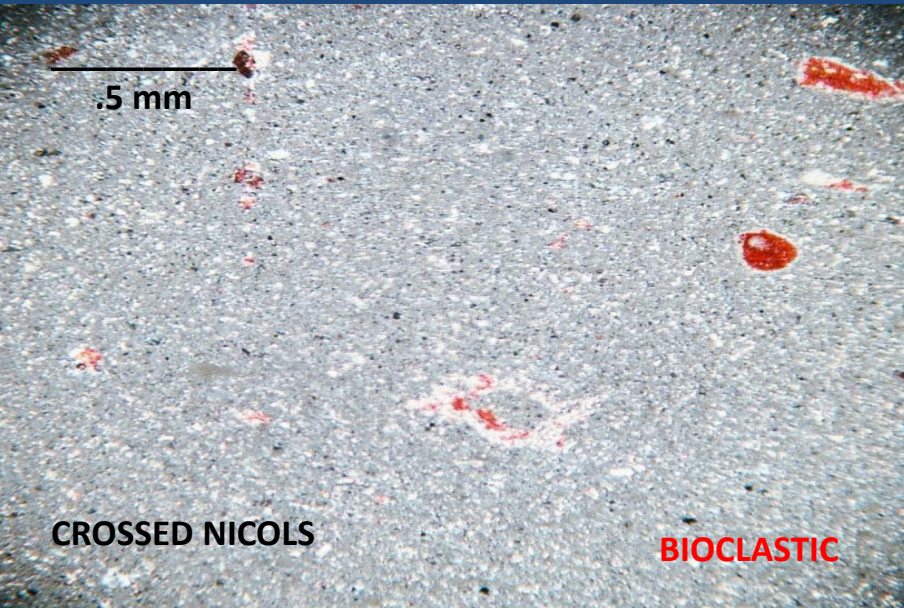
SPRING VALLEY QUARRY, NORTHWESTERN ARKANSAS

PENECONTEMPORANEOUS CHERT – LOWER BOONE – MAXIMUM FLOODING INTERVAL



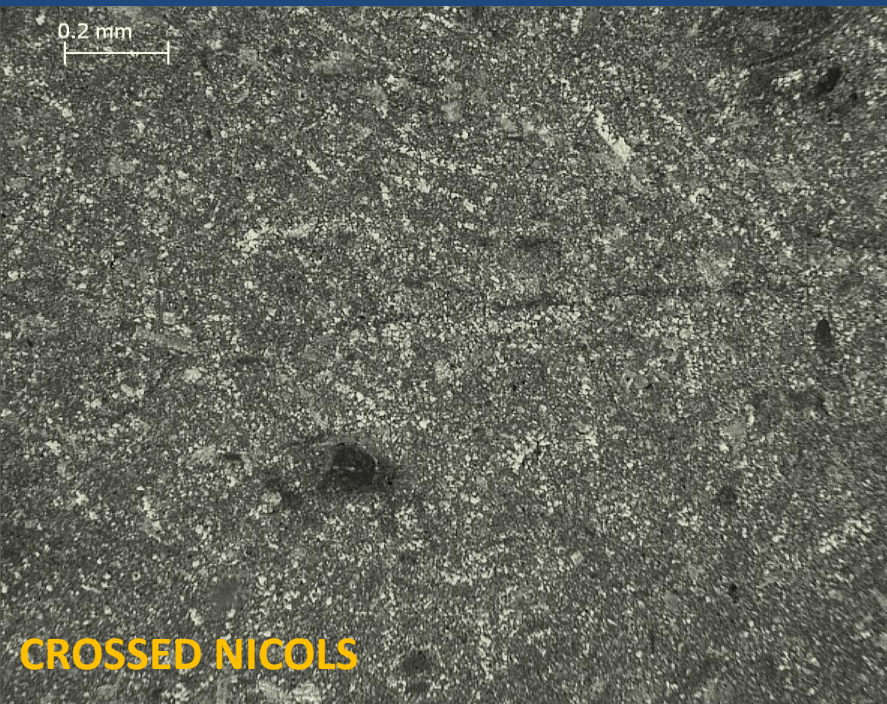
Opal – A → Opal – CT → Chalcedony → Quartz
Shrinkage fractures from de-watering

CHERT TEXTURAL SPECTRUM - LOWER BOONE = REEDS SPRING INTERVAL

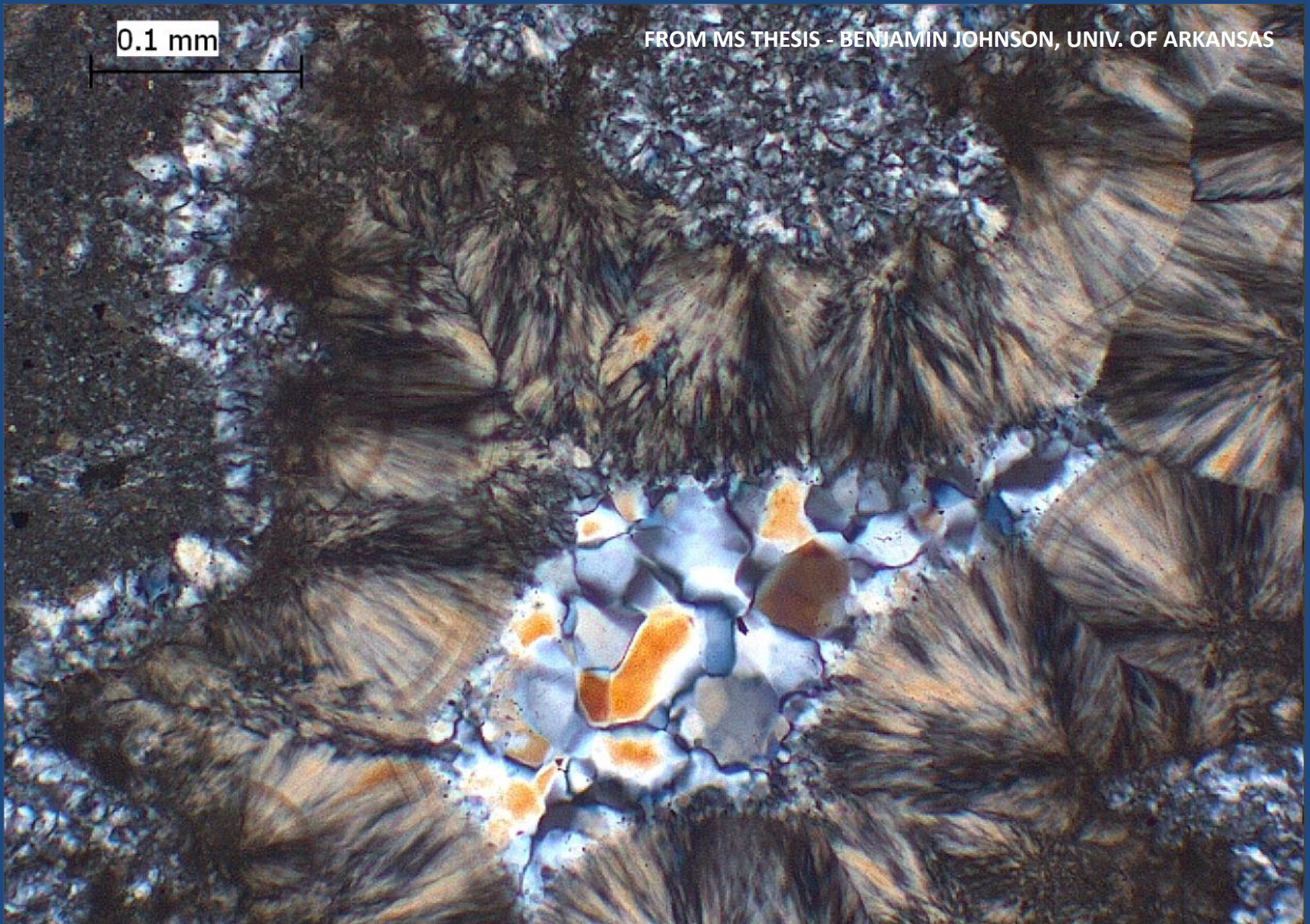


THIN SECTIONS OF PENECONTEMPORANEOUS CHERT

**SPICULITIC CHERT –
SPICULES PROBABLY NUCLEATED SILICA
PRECIPITATION ▼**

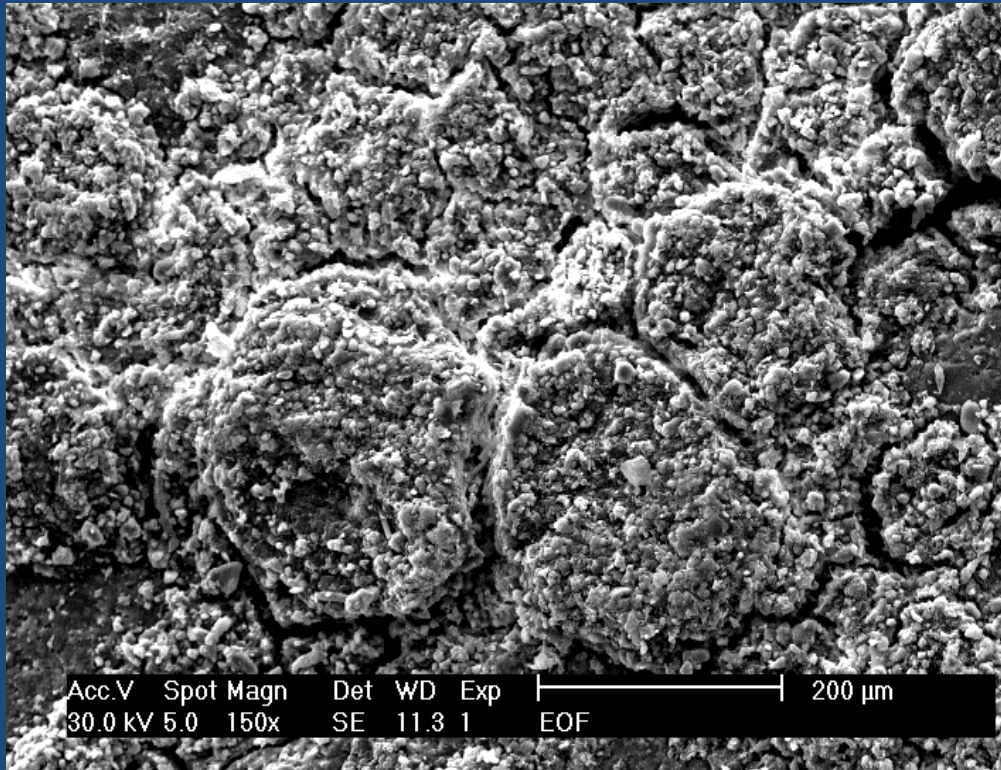


**LOWER BOONE - SPRING
VALLEY QUARRY**

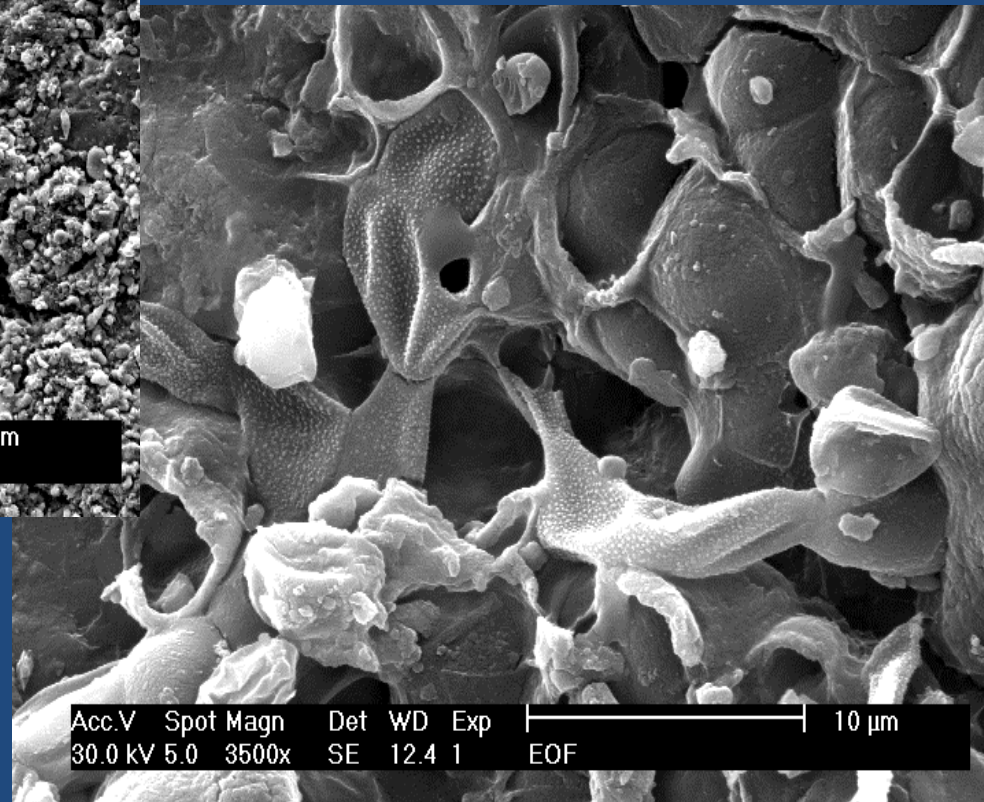


A thing of beauty is a joy forever: Its loveliness increases; it will never pass into nothingness.... Endymion - John Keats, 1818

SEM IMAGES – PENECONTEMPORANEOUS CHERT



▼ HIGH ORGANIC CONTENT –
CYANOBACTERIA?



▲ LEISPHERES? AND
PSEUDO – NOVACULITE TEXTURE?

LOWER BOONE – BELLA VISTA ROADCUT, ARKANSAS

TRANSITION ZONE – UPPER BOONE = ELSEY FORMATION – MAXIMUM FLOODING TO HIGHSTAND



**ELSEY - White, Nodular, Non-tripolitic
Chert Transitional into Later Diagenetic
Tripolitic Chert**



LATER DIAGENETIC CHERT – UPPER BOONE – HIGHSTAND/REGRESSION

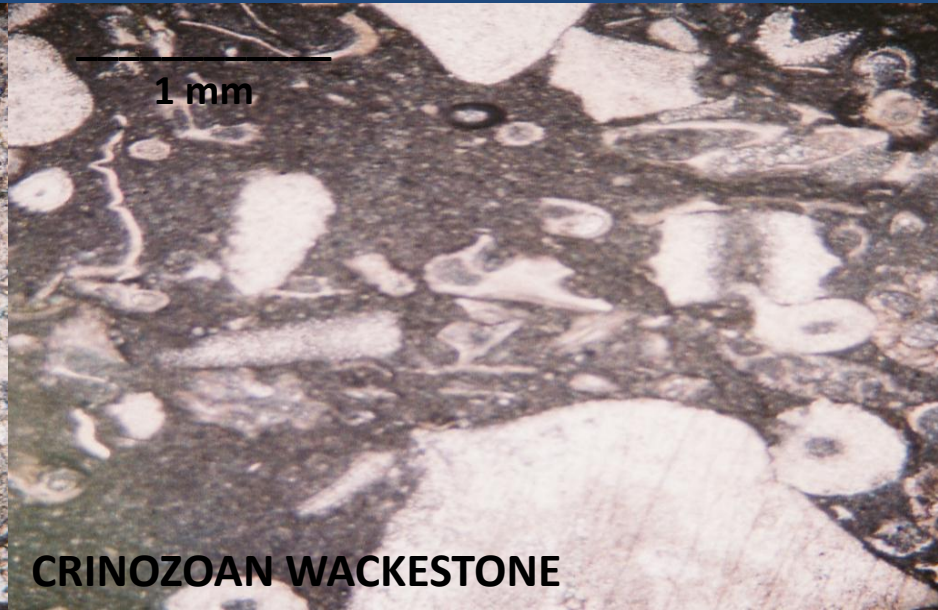


Highstand /Regression Lower
Mississippian
Third-order Cycle

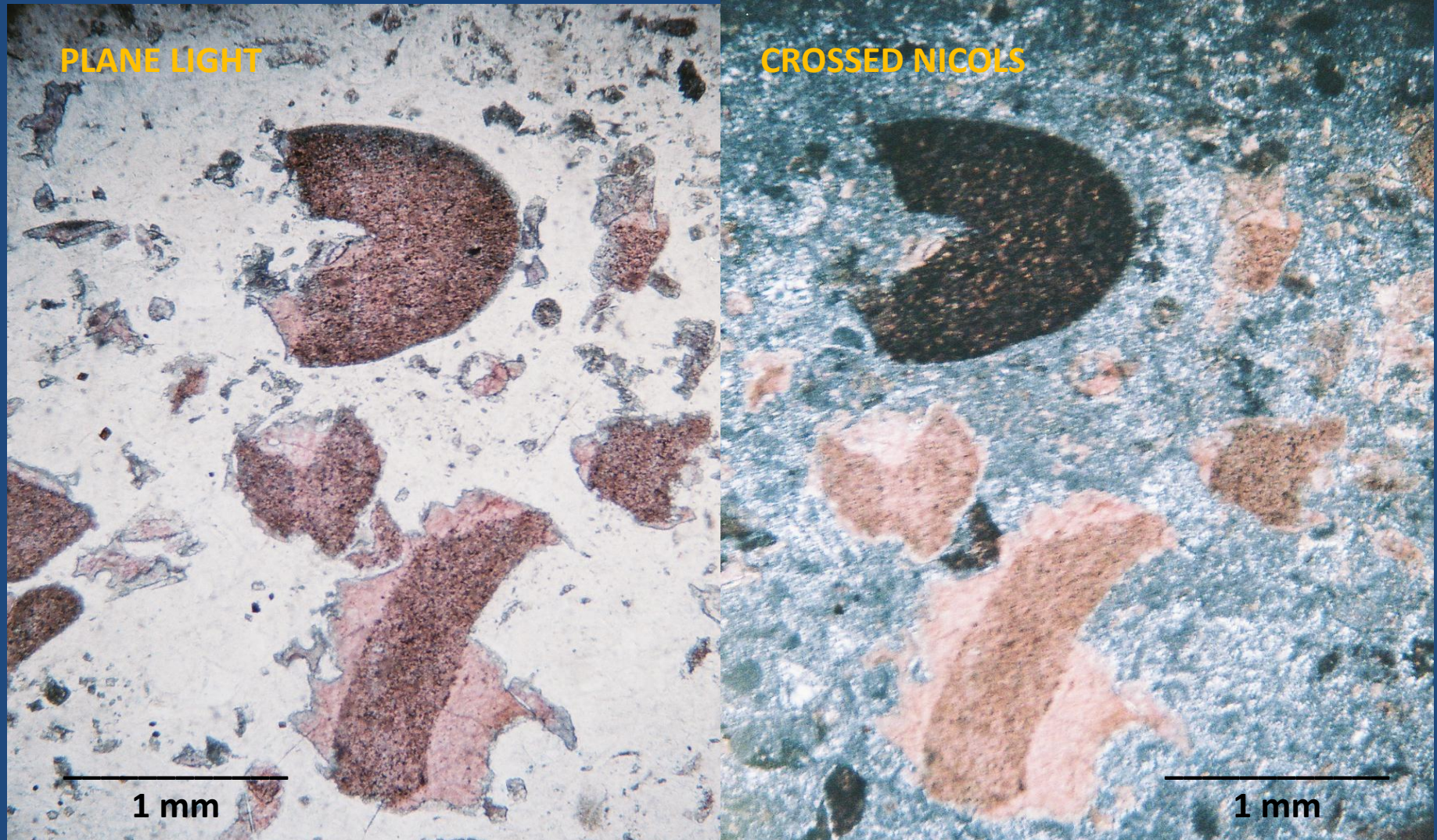
Groundwater Replacement of
Limestone by White, Later
Diagenetic Chert Along
Bedding Planes



CARBONATE TEXTURAL SPECTRUM - UPPER BOONE = BURLINGTON- KEOKUK INTERVAL

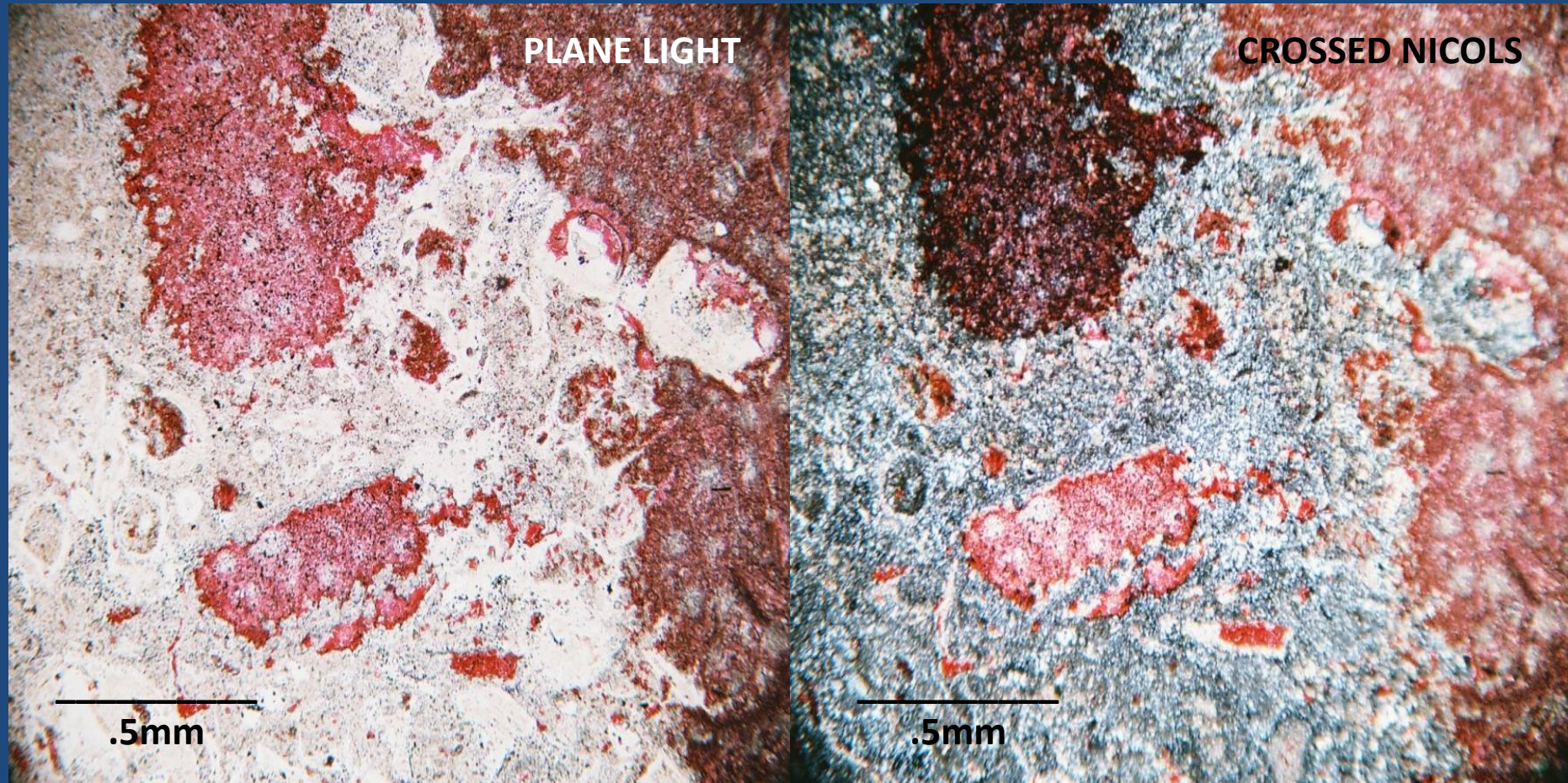


NON-TRIPOLITIC, LATER DIAGENETIC CHERT REPLACING COARSE CRINOZOAN WACKESTONE – UPPER BOONE



UPPER BOONE FORMATION – FAYETTEVILLE, ARKANSAS

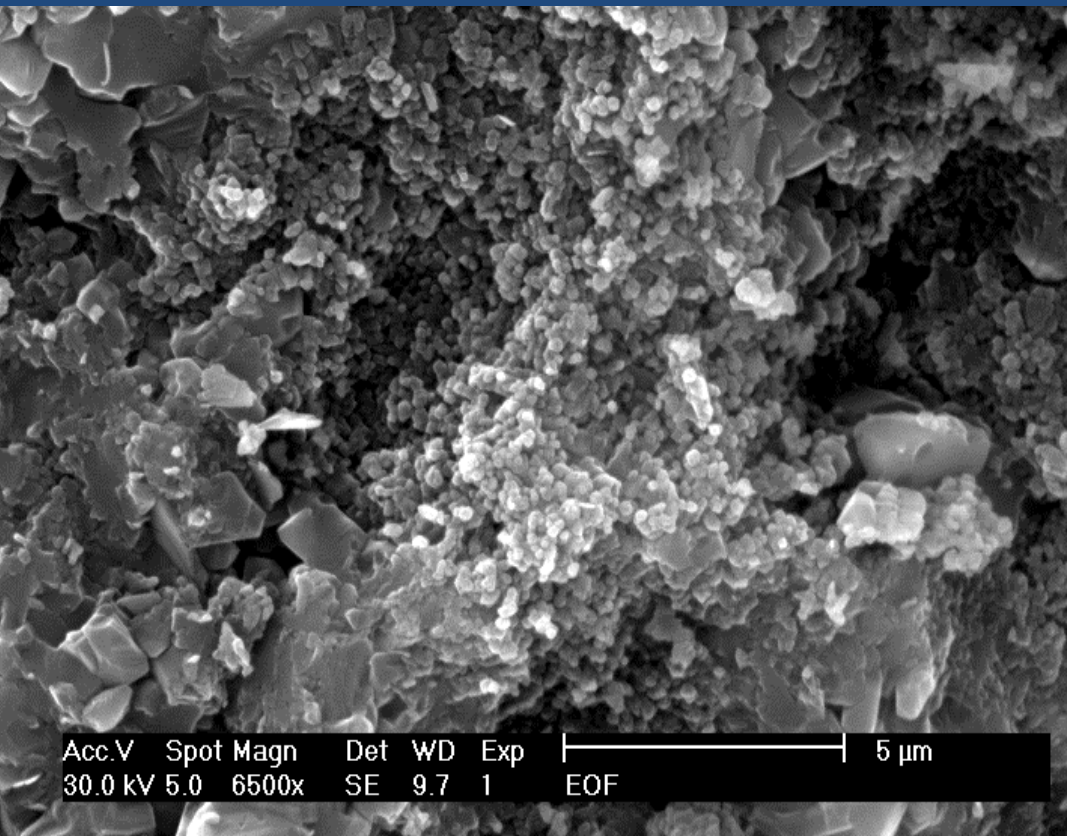
SILICIFICATION FRONT, LATER DIAGENETIC CHERT REPLACING CRINOZOAN WACKESTONE – UPPER BOONE



UPPER BOONE FORMATION – FAYETTEVILLE, ARKANSAS

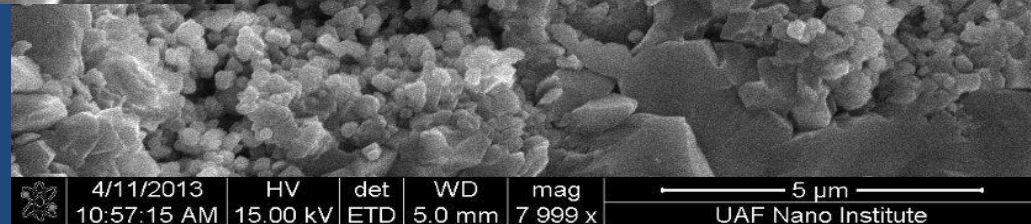
SEM IMAGES – LATER DIAGENETIC CHERT

Chert with Lepispheres? in contact
with Calcite Crystals, actually
forming Calcsiltites



Acc.V Spot Magn Det WD Exp | 5 μ m
30.0 kV 5.0 6500x SE 9.7 1 EOF

▲ Very High Magnification of
Chert/Carbonate contacts ►



UPPER BOONE – BELLA VISTA, ARKANSAS and PINEVILLE,
MISSOURI

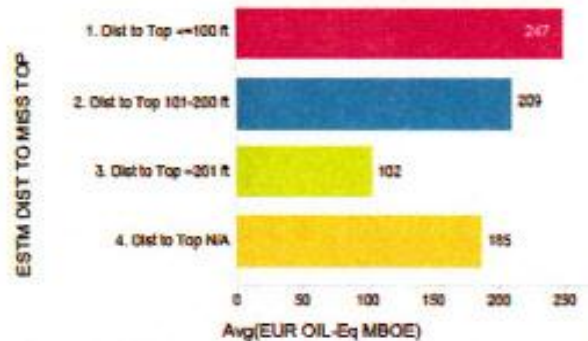
SIGNIFICANT OBSERVATIONS ON THE CHARACTER OF TRIPOLITIC CHERT DEVELOPMENT IN THE LOWER MISSISSIPPIAN SUCCESSION, SOUTHERN MIDCONTINENT

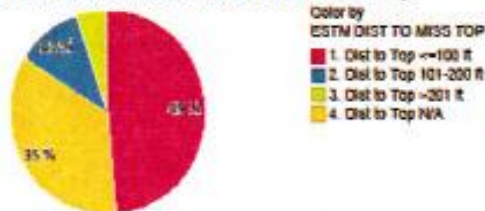
- ▶ Tripolitic Chert forms by decalcification (Tarr, 1936; 1938) – removal by groundwater solution of carbonate grains, mostly bioclastic, included within the chert
- ▶ There is not a high enough percentage of carbonate in typical Reeds Spring penecontemporaneous chert or in the transitional zone to produce tripolitic chert; in the Lower Mississippian succession of the southern midcontinent, the only chert that contains enough carbonate to be leached and form tripolitic chert is found in the Upper Boone Formation = Elsey, Burlington-Keokuk Formations
- ▶ Through 2012, 60% of the completions in the Lower Mississippian play were in the top 150 feet (Dick, 2012)
- ▶ In the Ouachita region, tripolitic chert development in the Arkansas Novaculite is restricted to its upper division, which turns out to be calcareous as well

SIGNIFICANT OBSERVATIONS ON THE CHARACTER OF TRIPOLITIC CHERT DEVELOPMENT IN THE LOWER MISSISSIPPIAN SUCCESSION, SOUTHERN MIDCONTINENT, cont.

- ▶ Tripolitic chert formation in the Lower Mississippian is most easily understood as a Paleozoic unconfined aquifer system
- ▶ The phreatic zone rests on the Reeds Spring = Lower Boone penecontemporaneous chert and dense calcisiltites, which is an aquaclude or aquatard with low porosity and permeability
- ▶ The top of tripolitic zone locally marks the paleo-water table – contact of the phreatic and vadose zones
- ▶ The vadose zone comprises the non-tripolitic intervals in the Elsey, Burlington/Keokuk = Upper Boone
- ▶ Perched water could produce local, and multiple, tripolitic chert intervals above the level of the paleo-water table

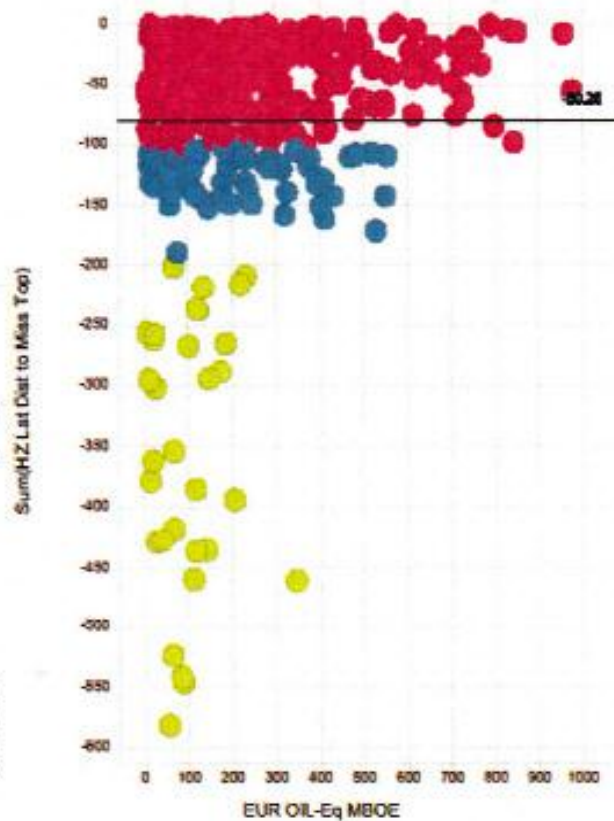
AVG EUR





ESTM DIST TO MISS TOP	Avg(EUR OIL-Eq MBOE)	Count(LEASE NAME)
1. Dist to Top <=100 ft	247	298
2. Dist to Top 101-200 ft	209	67
3. Dist to Top >201 ft	102	31
4. Dist to Top N/A	185	216
Grand total	214	612

Estimated Dist to Miss Top vs. EUR



Analyzing Depth of HZ Wells

Most wells concentrated in Top 150'

All Areas

All Operators

Varying Lithologies

Varying Completion Methods

J.P. Dick, 2012

**BURLINGTON/KEOKUK = UPPER BOONE = HIGHSTAND/REGRESSION – BELLA
VISTA ROADCUT, ARKANSAS**



**BURLINGTON/KEOKUK
= UPPER BOONE**

TRIPOLITIC CHERT

BELLA VISTA ROADCUT, ARKANSAS

TRIPOLIC CHERT RESERVOIR – HIGHSTAND/REGRESSION – UPPER BOONE



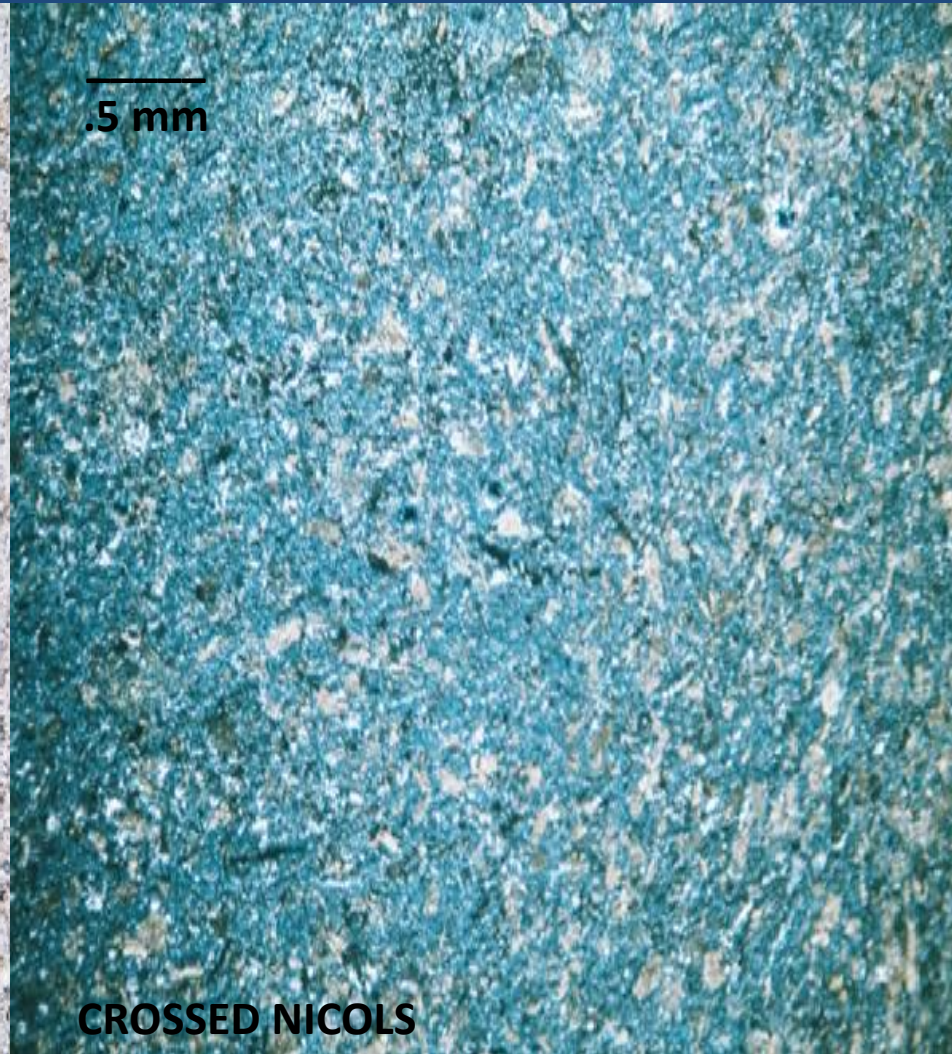
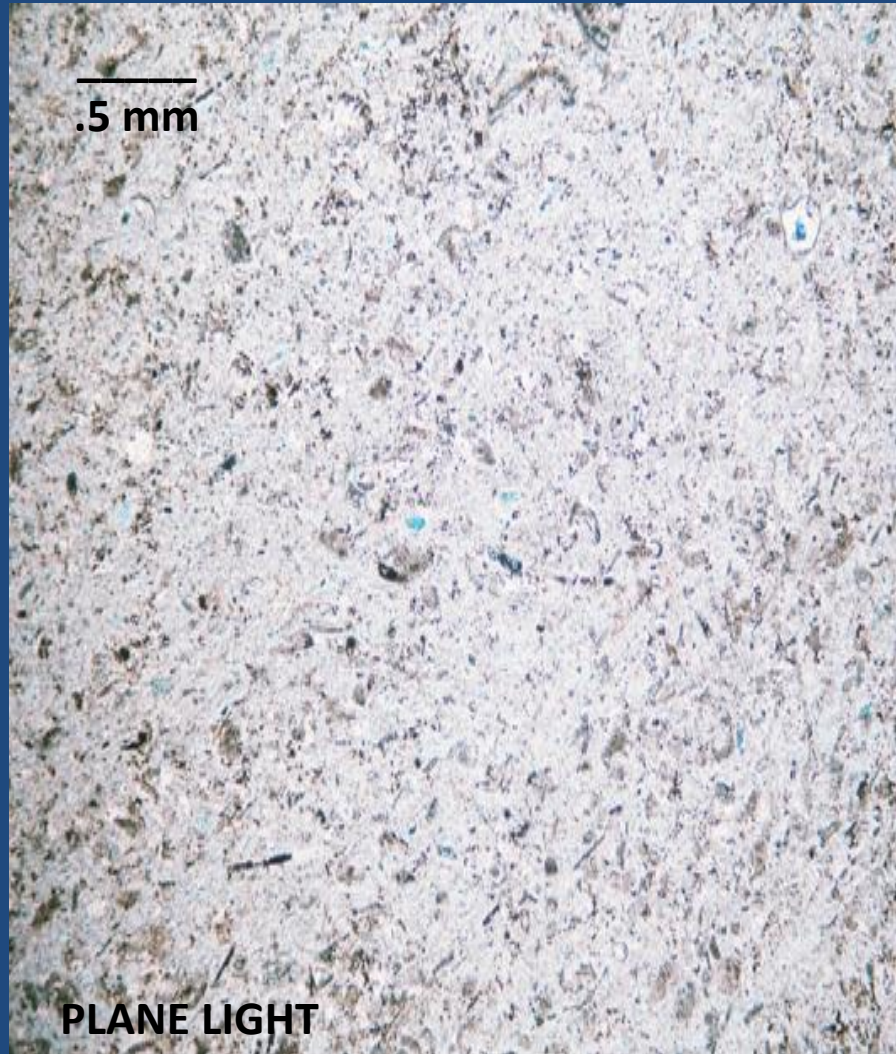
Bella Vista Roadcut



Pineville Roadcut

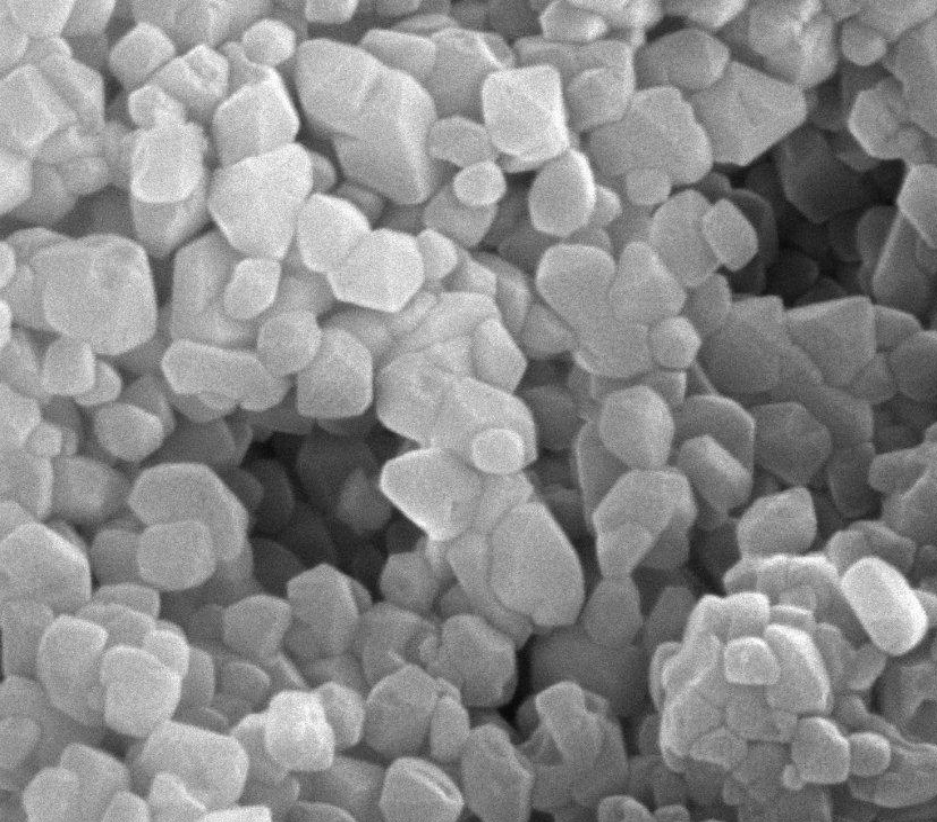
LIGHT = TRIPOLITIC CHERT / DARK = LIMESTONE
TRIPOLITIC CHERT DEVELOPS ONLY IN CALCAREOUS INTERVALS

TRIPOLITIC, LATER DIAGENETIC CHERT REPLACING VERY FINE BIOCLASTIC PACKSTONE



UPPER BOONE FORMATION - BELLA VISTA ROADCUT

SEM IMAGES OF MICROGRANULAR TRIPOLITIC CHERT

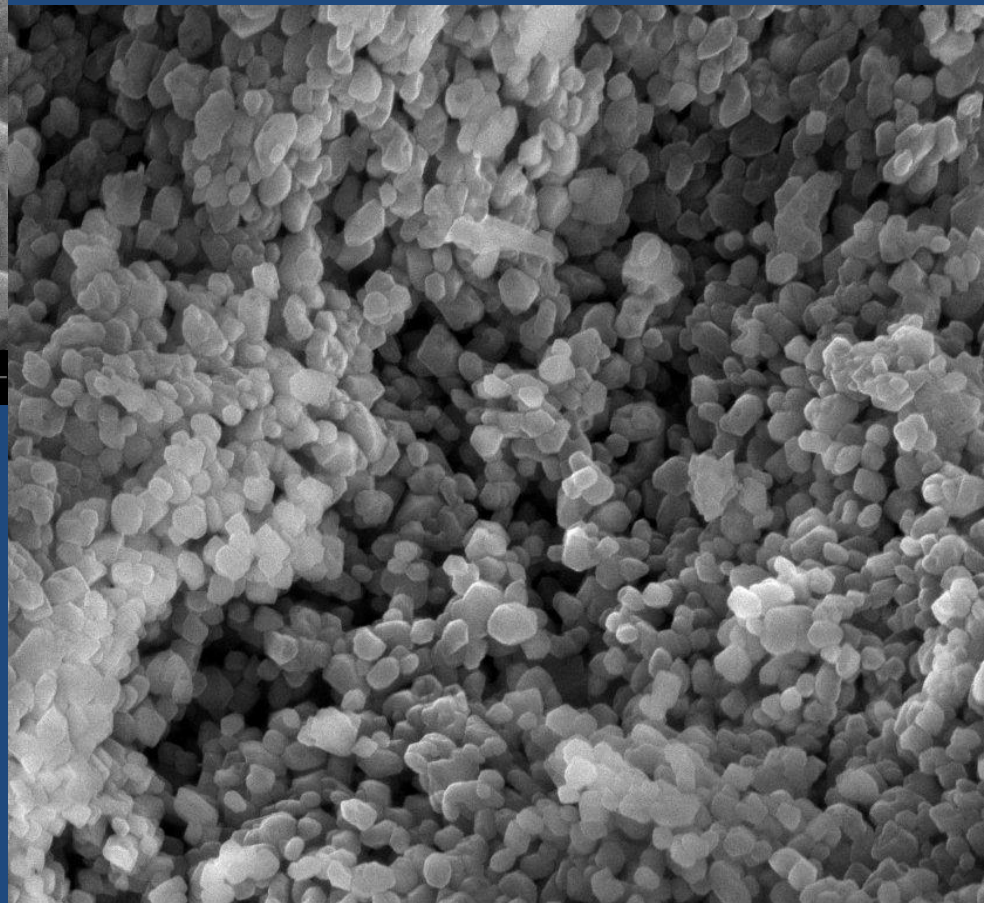


5/15/2013	HV	det	WD	mag	1 μ m
11:00:19 AM	15.00 kV	ETD	5.0 mm	34 993 x	UAF Nano Institute

▲ Upper Boone = Elsey
Pineville, Missouri – 34993x

Upper Boone = Elsey
Bella Vista, Arkansas - 14999x ►

NOTE: Extremely High Magnifications

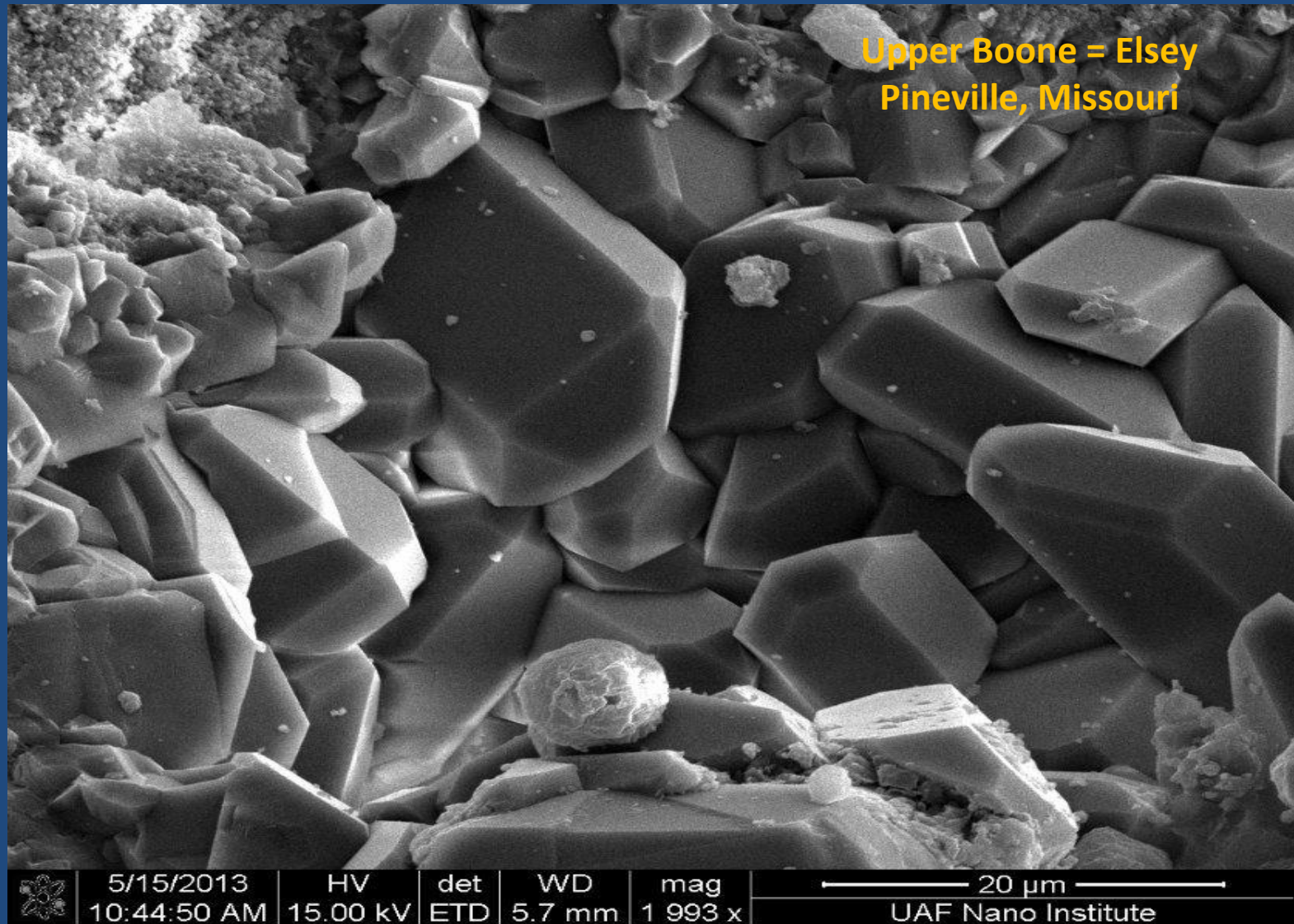


5/15/2013	HV	det	WD	mag	3 μ m
12:08:05 PM	15.00 kV	ETD	7.5 mm	14 999 x	UAF Nano Institute

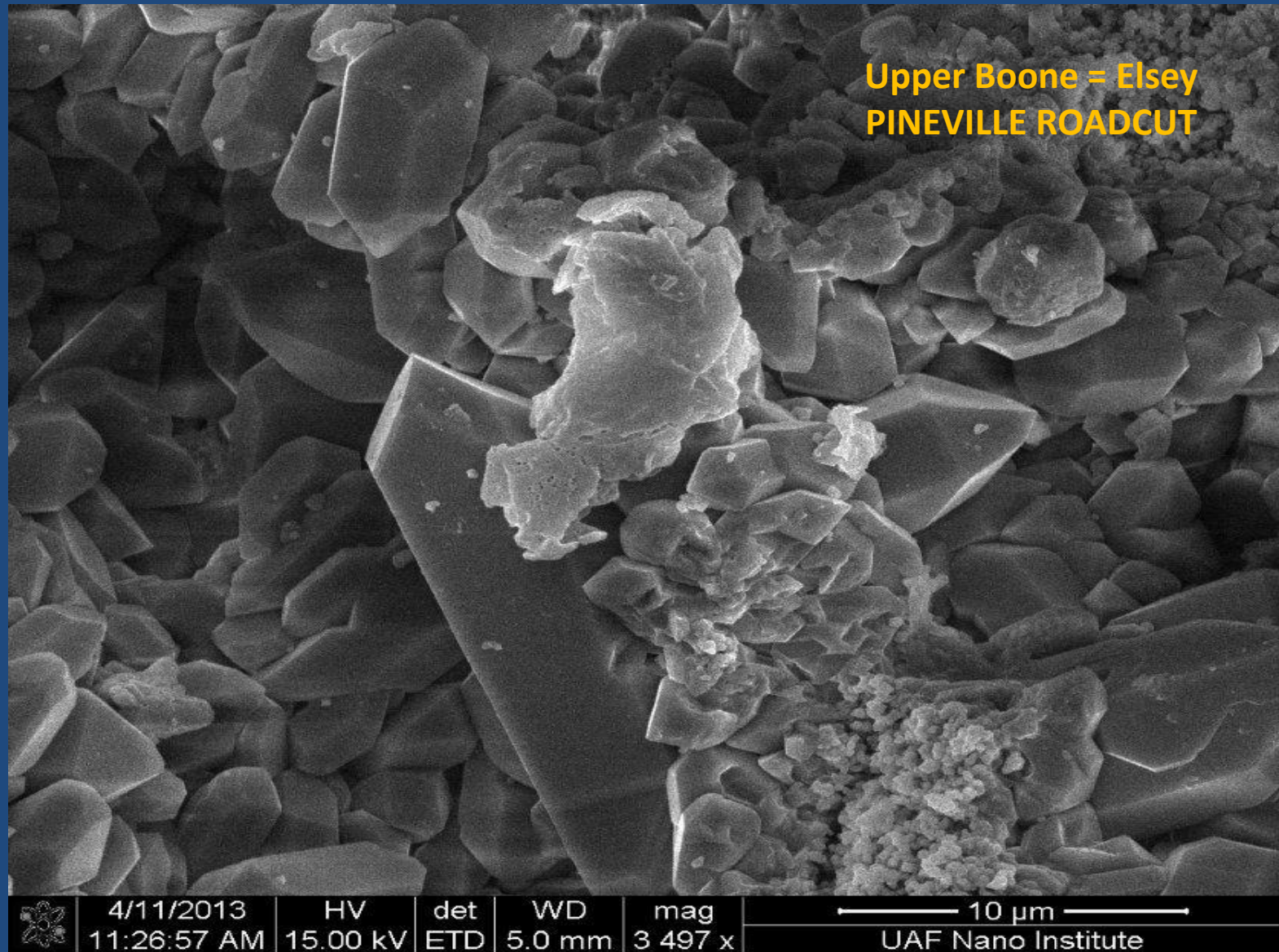
SIGNIFICANT OBSERVATIONS ON THE CHARACTER OF TRIPOLITIC CHERT DEVELOPMENT IN THE LOWER MISSISSIPPIAN SUCCESSION, SOUTHERN MIDCONTINENT, cont.

- ▶ The tripolitic chert interval experienced a second invasion by silica-bearing, hydrothermal water that allowed a druse of euhedral quartz crystals to form in the voids left by decalcification
- ▶ This hydrothermal water is probably the same medium that deposited the lead and zinc in the tri-state region, Oklahoma, Kansas, Missouri
- ▶ The combination of these observations/relationships suggests that the age of tripolitic chert formation is certainly Paleozoic, and could be Upper Mississippian age, related to “Mississippi Chat” formation

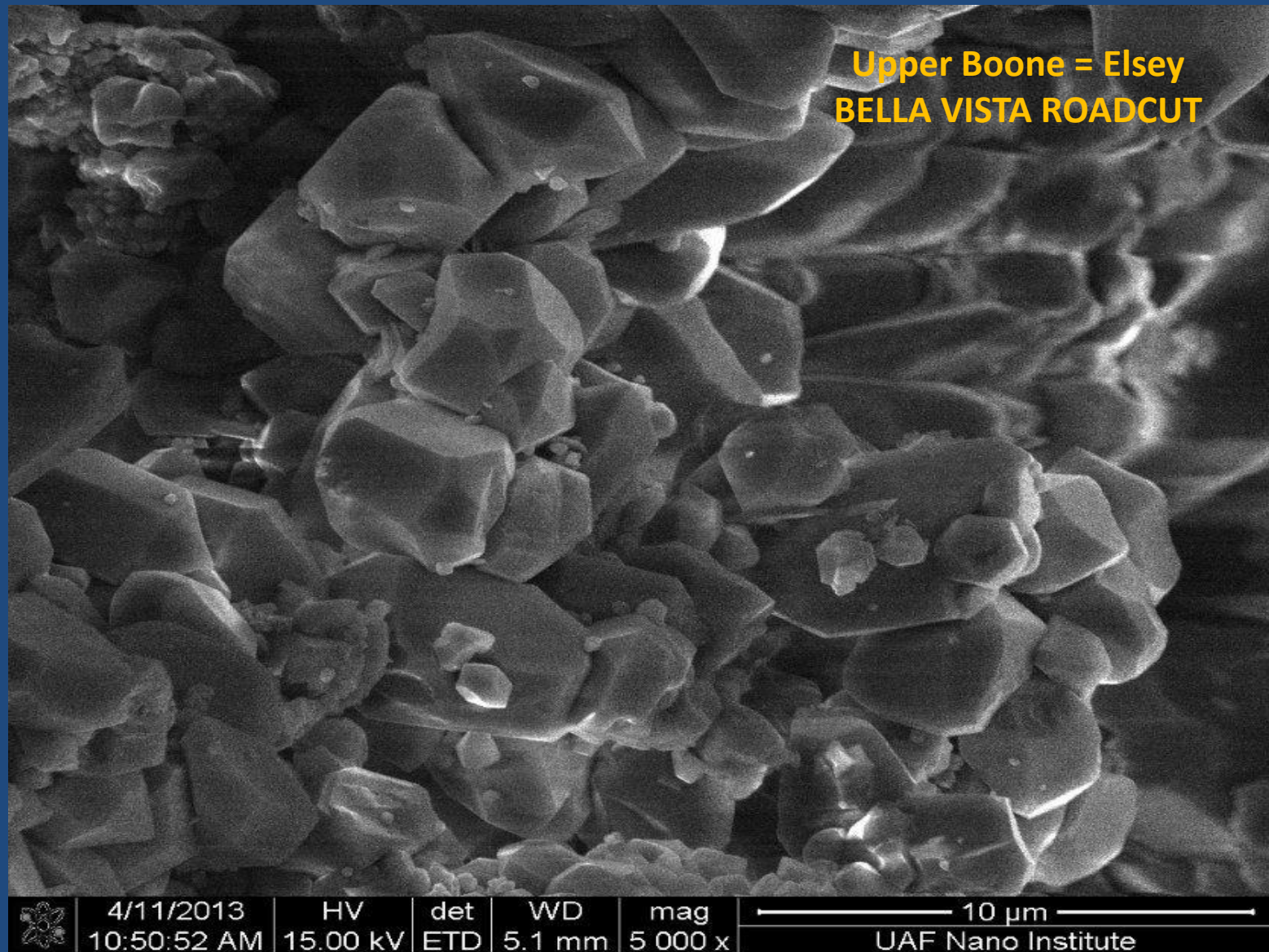
TRIPOLITIC CHERT CAVITY FILLED WITH EUHEDRAL QUARTZ CRYSTALS



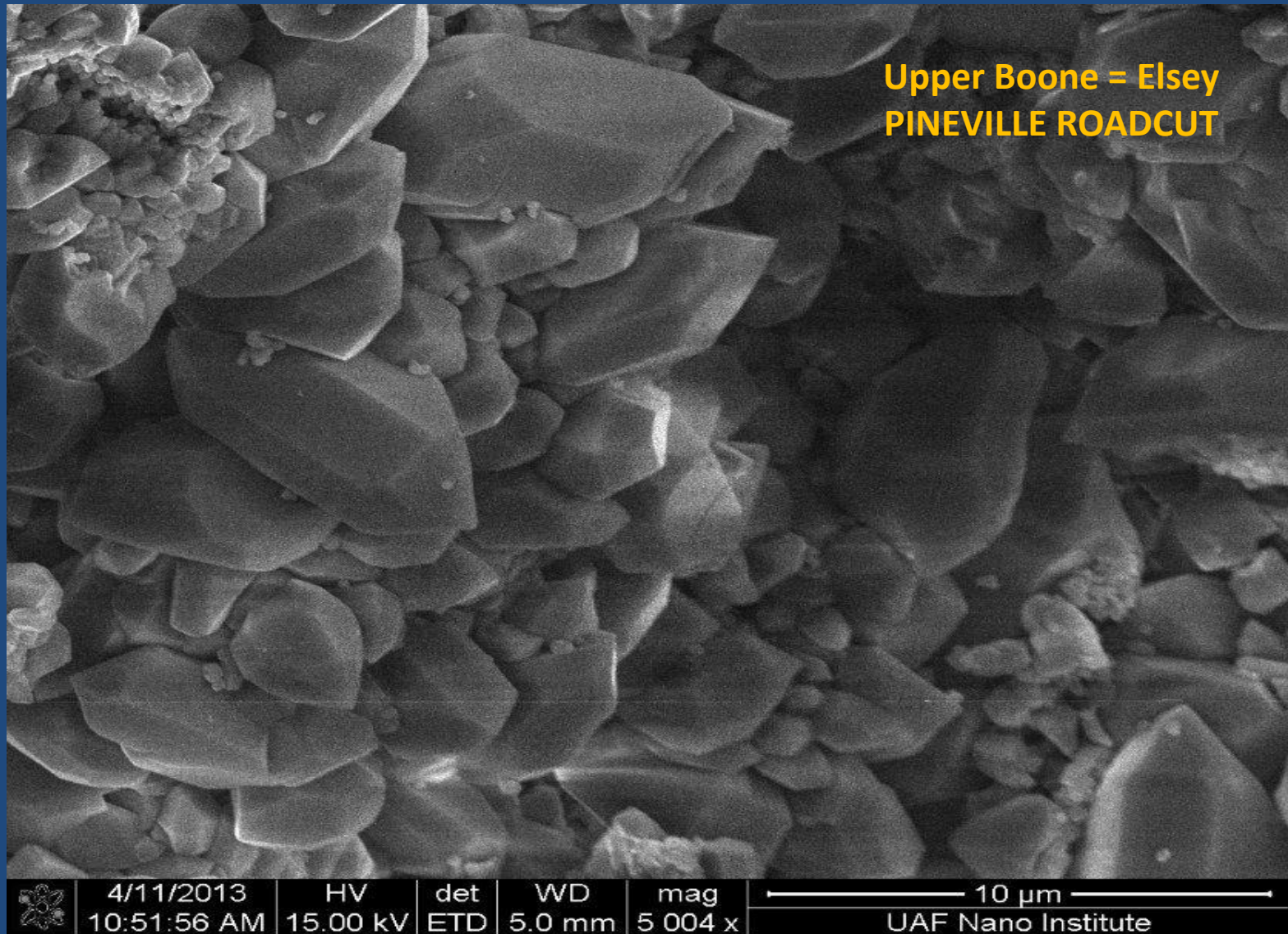
TRIPOLITIC CHERT CAVITY FILLED WITH EUHEDRAL QUARTZ CRYSTALS



TRIPOLITIC CHERT CAVITY FILLED WITH EUHEDRAL QUARTZ CRYSTALS



TRIPOLITIC CHERT CAVITY FILLED WITH EUHEDRAL QUARTZ CRYSTALS





CHERT BRECCIA – HINDSVILLE LIMESTONE – CHESTERIAN



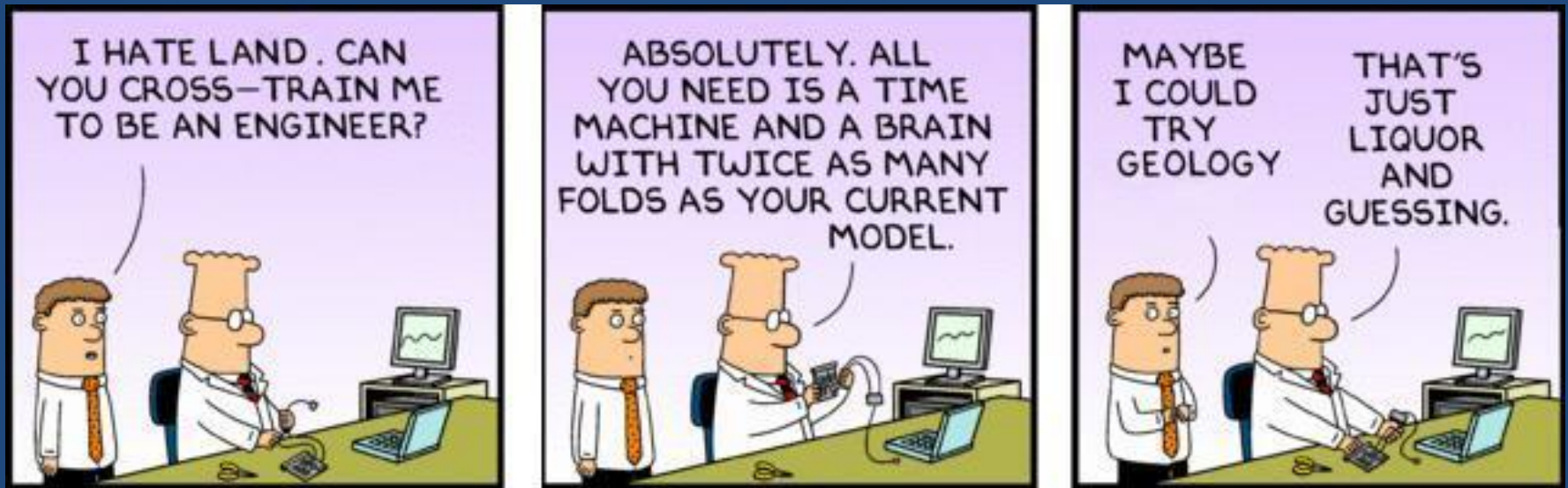
ELKINS ROADCUT EXPOSURES,
WASHINGTON COUNTY, ARKANSAS

THE FINAL CONUNDRUM – ORIGIN OF THE BOONE REGOLITH?

Thick, Chert-bearing, Clay-rich
Regolith Mantles The Boone
Formation Across the Southern
Ozark Region



SHARPS QUARRY, BENTON
COUNTY, NORTHWESTERN
ARKANSAS



THANKS!!

Dr. Susan Nash - AAPG

Vicky Kroh - AAPG

All Participants



AAPG

FORUM