Stratigraphic Context of Dolomite in the Ste Genevieve Limestone of South Central Kentucky

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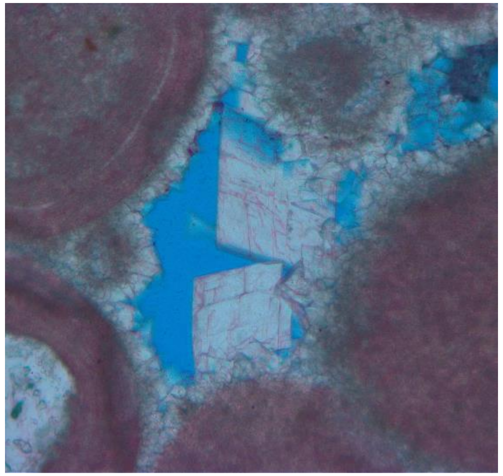
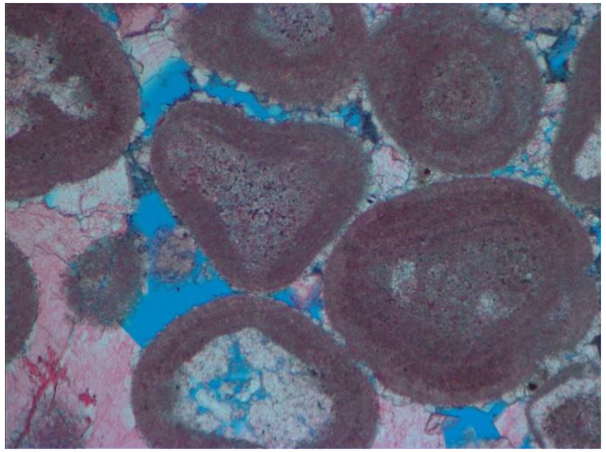
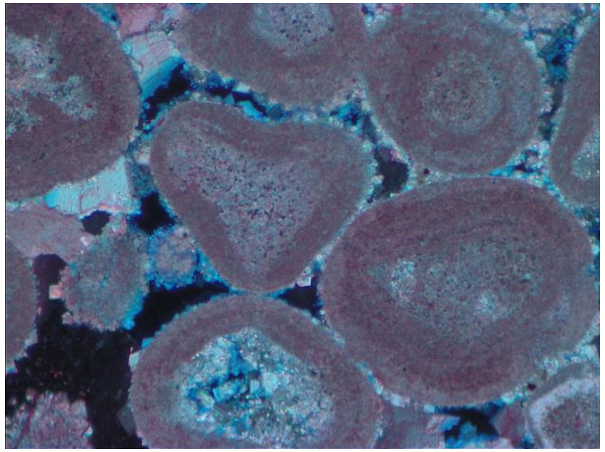






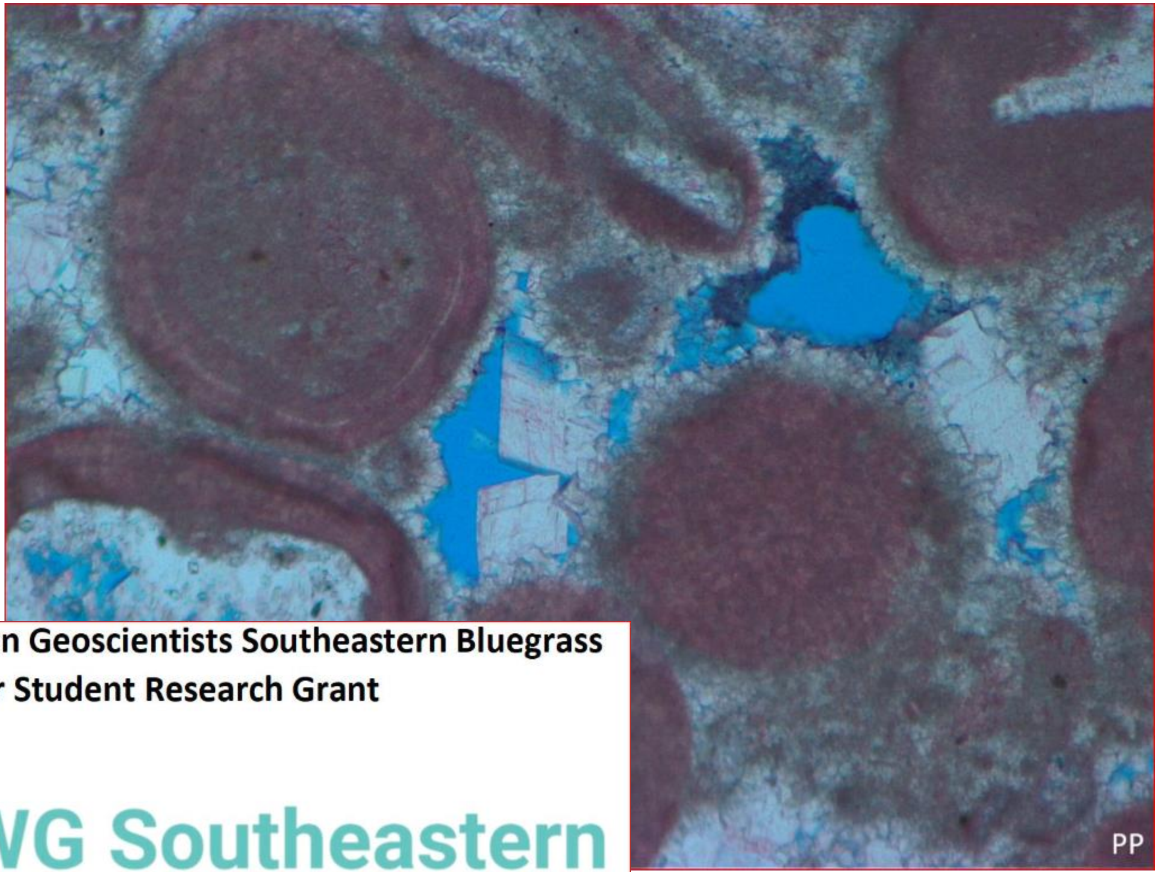
Ste Genevieve Stratigraphic Context of Dolomitic Units in South Central Kentucky

- Intro – Stratigraphic setting,

Past work in Dolomites

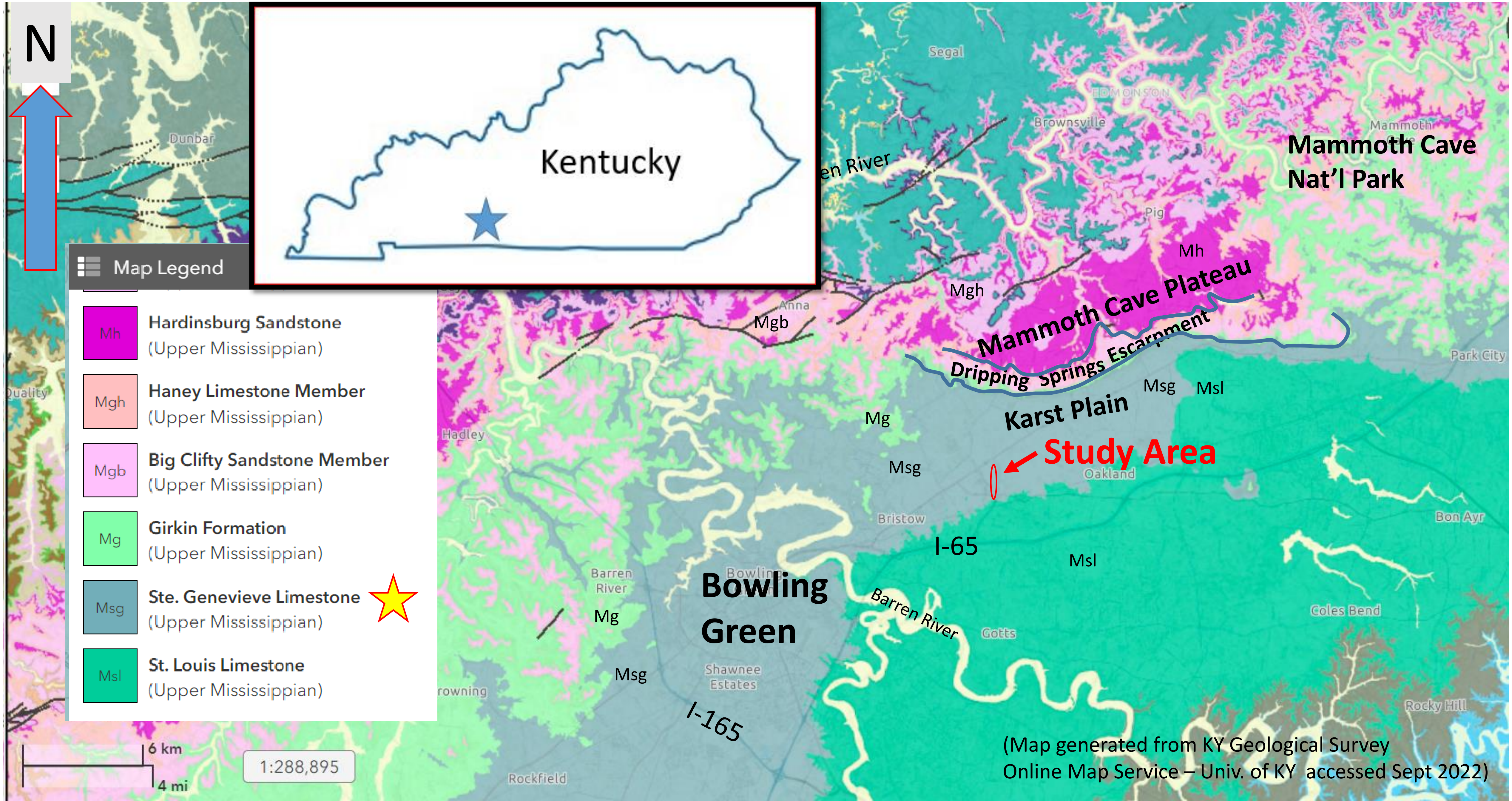
Recognition of Dolomite

- Methods
- Strat. context of Dolomite
- Summary & Conclusions
- Future Work
- Acknowledgement:



Association for Women Geoscientists Southeastern Bluegrass Chapter Student Research Grant

AWG Southeastern Bluegrass Chapter

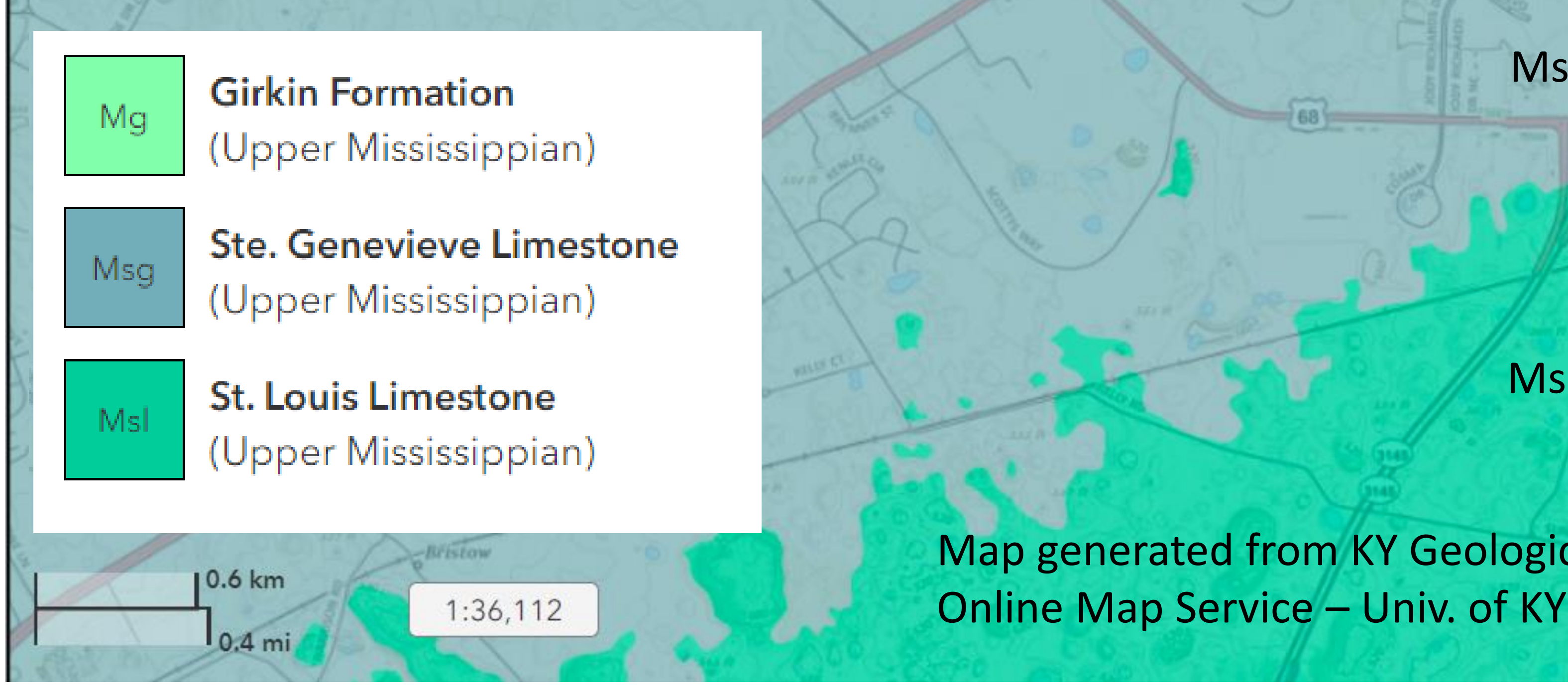


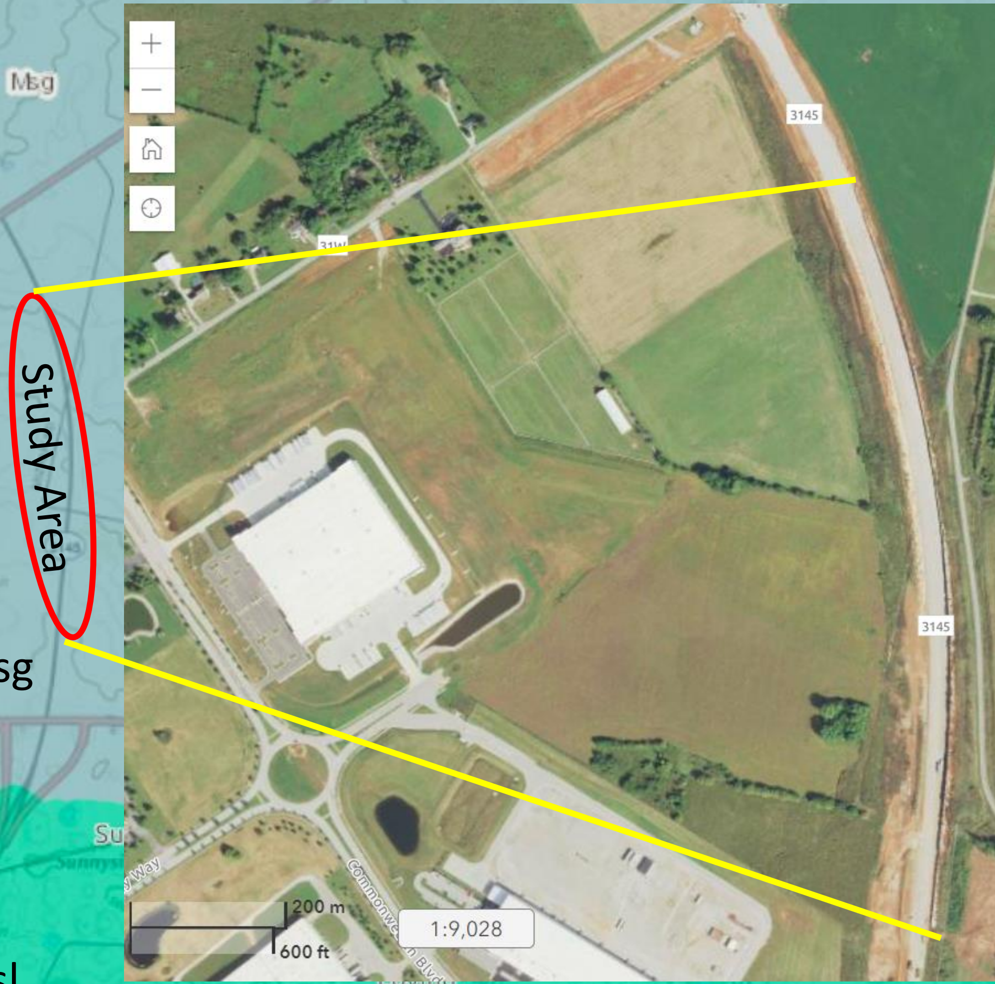
N
Kentucky
Map Legend
Mh
Hardinsburg Sandstone
(Upper Mississippian)
Mgh
Haney Limestone Member
(Upper Mississippian)
Mgb
Big Clifty Sandstone Member
(Upper Mississippian)
Mg
Girkin Formation
(Upper Mississippian)
Msg
Ste. Genevieve Limestone
(Upper Mississippian)
Msl
St. Louis Limestone
(Upper Mississippian)
6 km
4 mi
1:288,895
Mammoth Cave
Nat'l Park
Mammoth Cave Plateau
Dripping Springs Escarpment
Karst Plain
Study Area
Mh
Mgh
Mgb
Mg
Msg
Msl
I-65
I-165
Bowling
Green
Barren River
Segal
Brownsville
Pig
Anna
Hadley
Oakland
Bristow
Park City
Bon Ayr
Coles Bend
Gotts
Shawnee
Estates
Rocky Hill
Rockfield
Dunbar
(Map generated from KY Geological Survey
Online Map Service – Univ. of KY accessed Sept 2022)

Questions – What is the stratigraphic distribution of dolomites in the Ste. Gene?

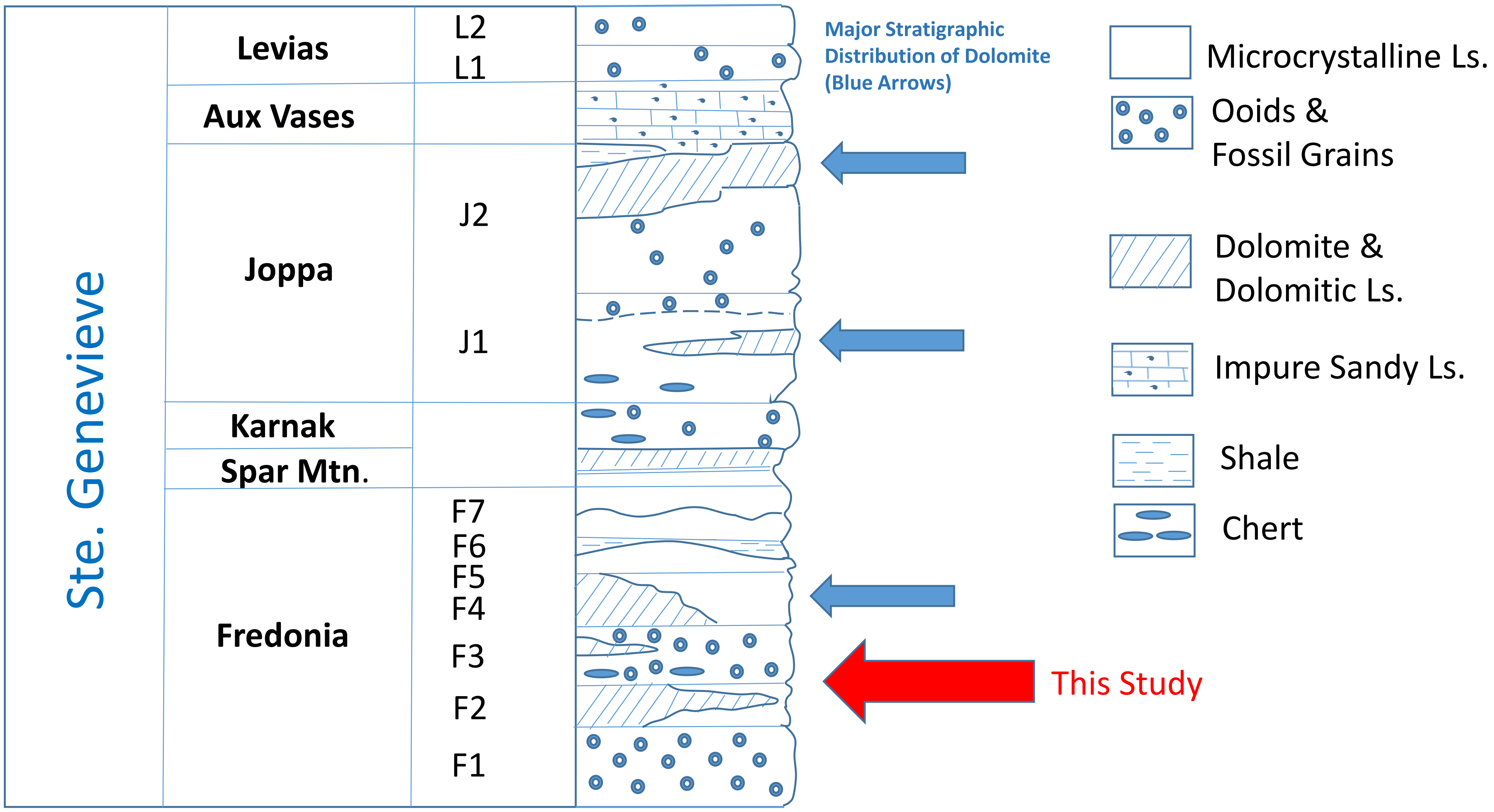
What appears to be the controls or influences on that distribution?

What is the nature of the mineralizing fluids for baroque dolomite in vugs, dolostone, or dolomitic limestone?





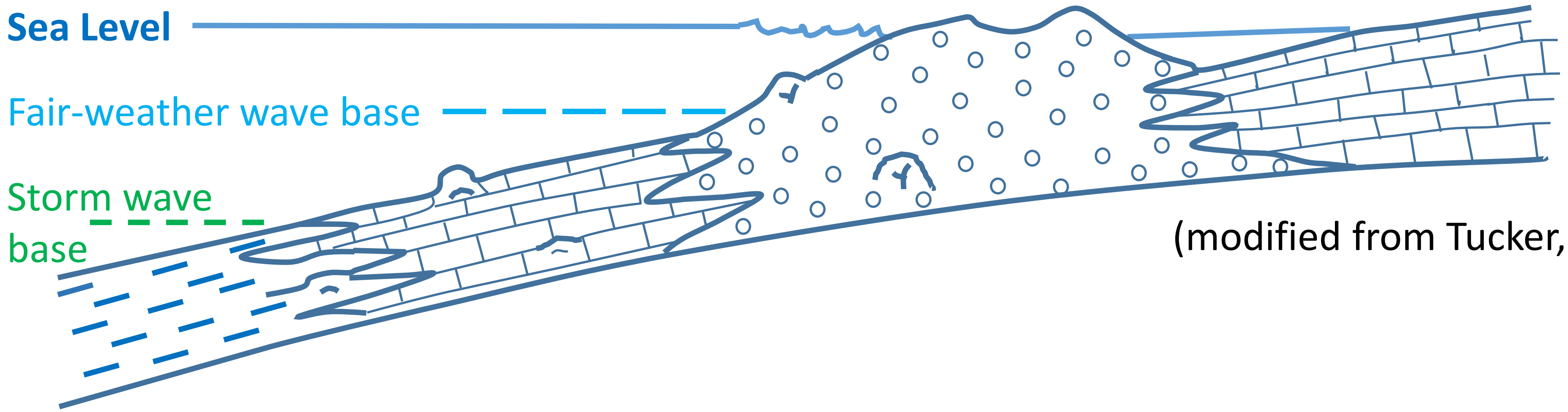
Map generated from KY Geological Survey Online Map Service – Univ. of KY accessed Sept 2022)



Modified from Palmer (1981)

Generalized model for a Carbonate Ramp – Typical of Ste. Gene. in Kentucky

BASIN	CARBONATE RAMP Deep Ramp	Shallow Ramp	Back Ramp
Below Fair weather Wave base		Wave-Dominated	Protected/Subaerial
Shale/ Pelagic Limestone	Thin bedded Ls. Storm Deposits +/- Mud Mounds	Beach-Barrier/ Strandplain/Sand Shoals Patch Reefs	Lagoonal-tidal Flat – Supratidal Carbonate, Evaporites, Paleosols, Paleokarst Surfaces
MDST	GRST/WKST/MDST	GRST	WKST/MDST



(modified from Tucker, 1991)

Previous Work on Dolomite Problem, Diagenetic Dolomite in KY & other regions

- Focus on Ste Gene Ls. but dolomitization noted in other Mississippian carbonates

- Recognition of dolomitization – most have focused on *reservoir rocks*

– e.g. Ellenberger studies in West Texas (Amthor and Friedman, 2006),
and Knox in Kentucky (Anderson, 1991) and Ordovician of Central KY (Black et al., 1981)

- Mississippian in South Central KY – some select examples:

➢ May & Kambesis (in progress 2022) Ste Gene Mammoth Cave – isolated dolomite units
➢ Creech (2019) MS thesis (WKU) on Ste Gene in Warren & Barren counties
➢ KY Geological Survey database for carbonate resources (quarry bench analyses)
➢ Devine (2016) MS thesis (WKU) on Haney Limestone near Mammoth Cave

– Focus on Ste Genevieve Stratigraphy – lower portion for this study
- a paucity of MVT minerals
– our study area possesses only localized dolomite zones

Black et al. (1981) - Central Kentucky (Bluegrass Region Ordovician- NE of this study)

- Dolomites - the general observation: downthrown sides of faults are preferentially dolomitized in most Kentucky occurrences

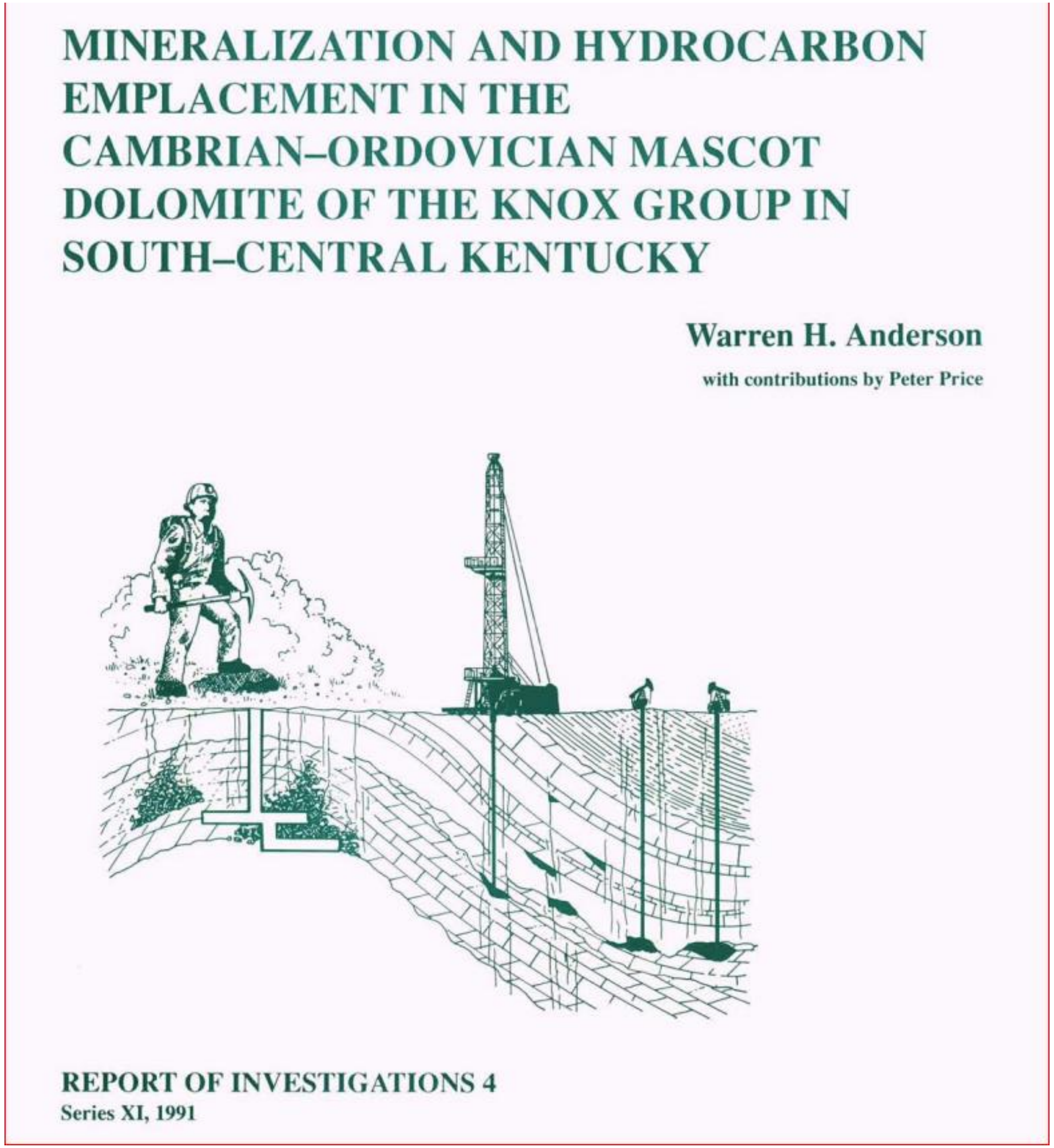
- Small displacement may have resulted from collapse caused by shrinkage brought about by dolomitization

- Cavity fillings of coarsely crystalline minerals: barite, dolomite, and calcite but are regional in occurrence and not demonstrably related to the dolomitization.

- Features indicating shrinkage include curved fractures peripheral to the body and calcite-filled gash fractures at a slightly greater distance from it; increased porosity near its center where open, as well as partly filled, fractures and vugs are present

Black et al. (1981) cont.

- Dolomitization appears to affect fine-grained argillaceous limestone at a greater distance from the source faults than it does the relatively coarse-grained limestone.
- Dolomitization can obliterate all traces of most fossils even in rocks wholly composed of fossils.
- Dolomitization modifies original bedding to such a degree that very irregularly bedded fossil fragmental limestone may be converted to evenly bedded dolomite.
- Porosity and permeability are increased, especially where the limestone is only partly dolomitized.
- Mineral- and petroleum-filled vugs appear to be commonly associated with this mode of dolomite emplacement.



MINERALIZATION AND HYDROCARBON EMPLACEMENT IN THE CAMBRIAN–ORDOVICIAN MASCOT DOLOMITE OF THE KNOX GROUP IN SOUTH–CENTRAL KENTUCKY

Warren H. Anderson

with contributions by Peter Price

REPORT OF INVESTIGATIONS 4
Series XI, 1991

Development of an erosional unconformity at the top of the Knox Group

- results: paleoaquifer and karst system created diagenetic changes

- migration avenues, and solution-collapse **breccias** controlled subsequent migration yields of base metals & HCs.

- Location of breccia-hosted ores was influenced by major and minor structural features & paleotopography.

- Latter related to the presence & subsequent dissolution of limestone (**now represented by dolomite)** and a dolomite-limestone transition

(Anderson, 1991 KY Geological Survey)

Methodology

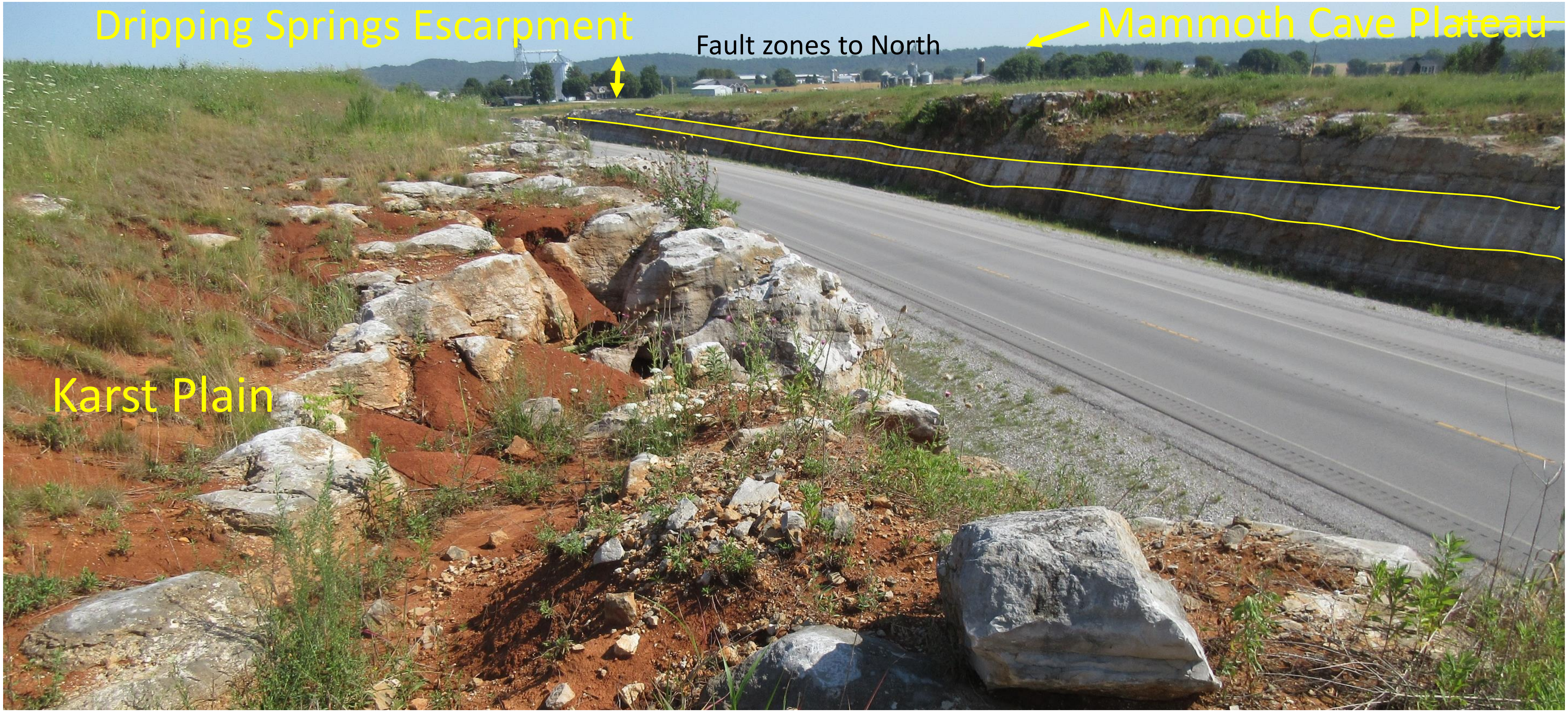
- **Standard Stratigraphic Section Measuring**
  – Lithology (Dunham Classification), Munsell Color, Basic Carbonate Mineralogy

- **Slab Study & Standard Petrographic Thin Section Study**
  - 8 thin sections from parts of section possessing dolomite, particularly baroque
  - range of depositional textures; variable mineralogy (Alizarin Red-S Staining)

- **Documentation of distribution of dolomite** – context of the depositional texture & stratigraphic position

- **Comparison to other dolomitized Mississippian units as well as other KY rocks**

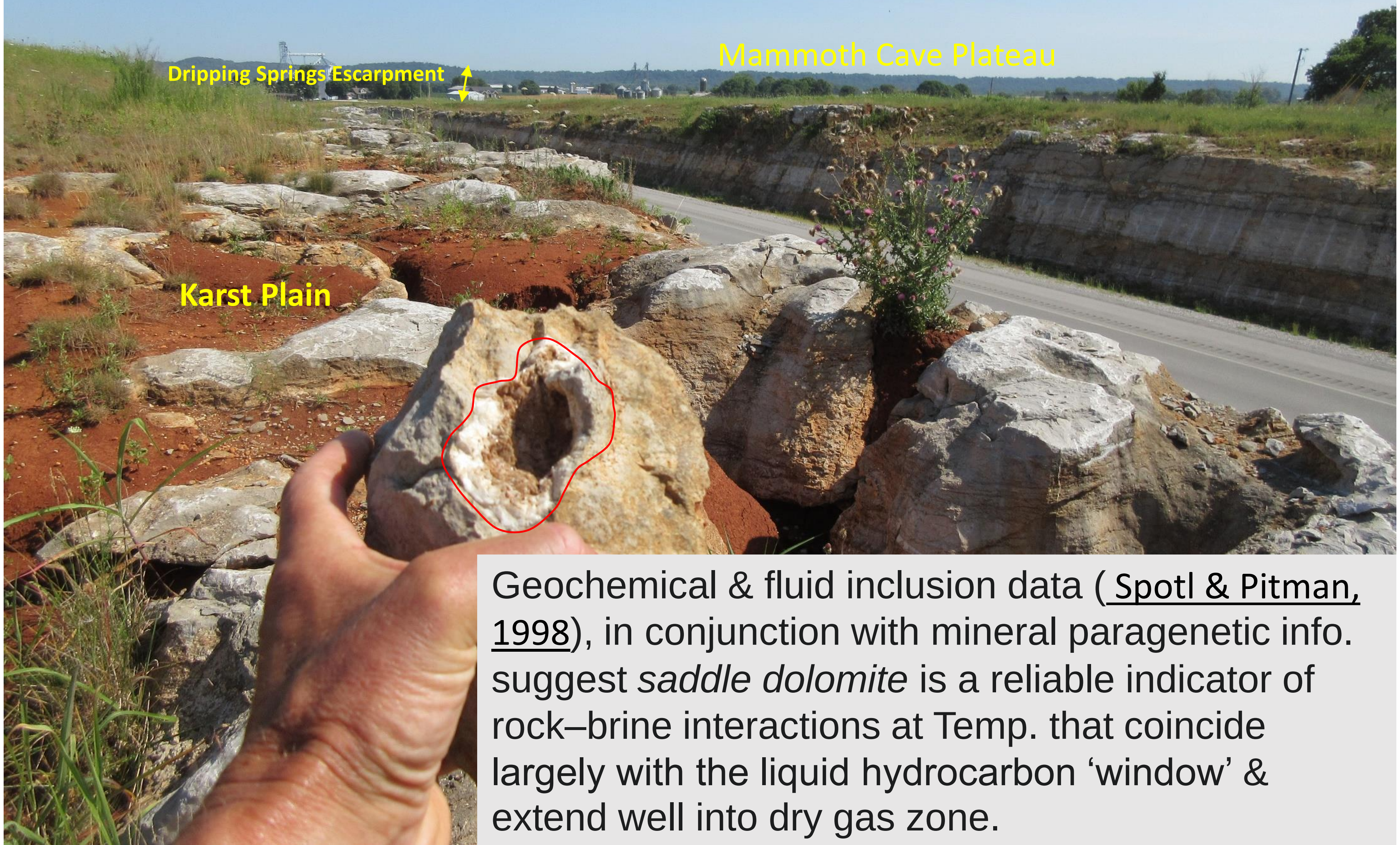
- **Review of Dolomite Models-** relative to findings from this study



Dripping Springs Escarpment
Fault zones to North
Mammoth Cave Plateau
Karst Plain


Levias
L2
L1
Aux Vases
Joppa
J2
J1
Karnak
Spar Mtn.
Fredonia
F7
F6
F5
F4
F3
F2
F1
Ooid Grainstone
Dolostone
Dolomite Vug
Ooid Grainstone

Defined Saddle (baroque) dolomite = coarse-crystalline dolospar with regularly to irregularly curved crystal boundaries and sweeping extinction. Noted as diagenetically altered carbonates and sandstones in
a) hydrocarbon reservoirs, b) paleoaquifers, and in 3) MVT-ore deposits.



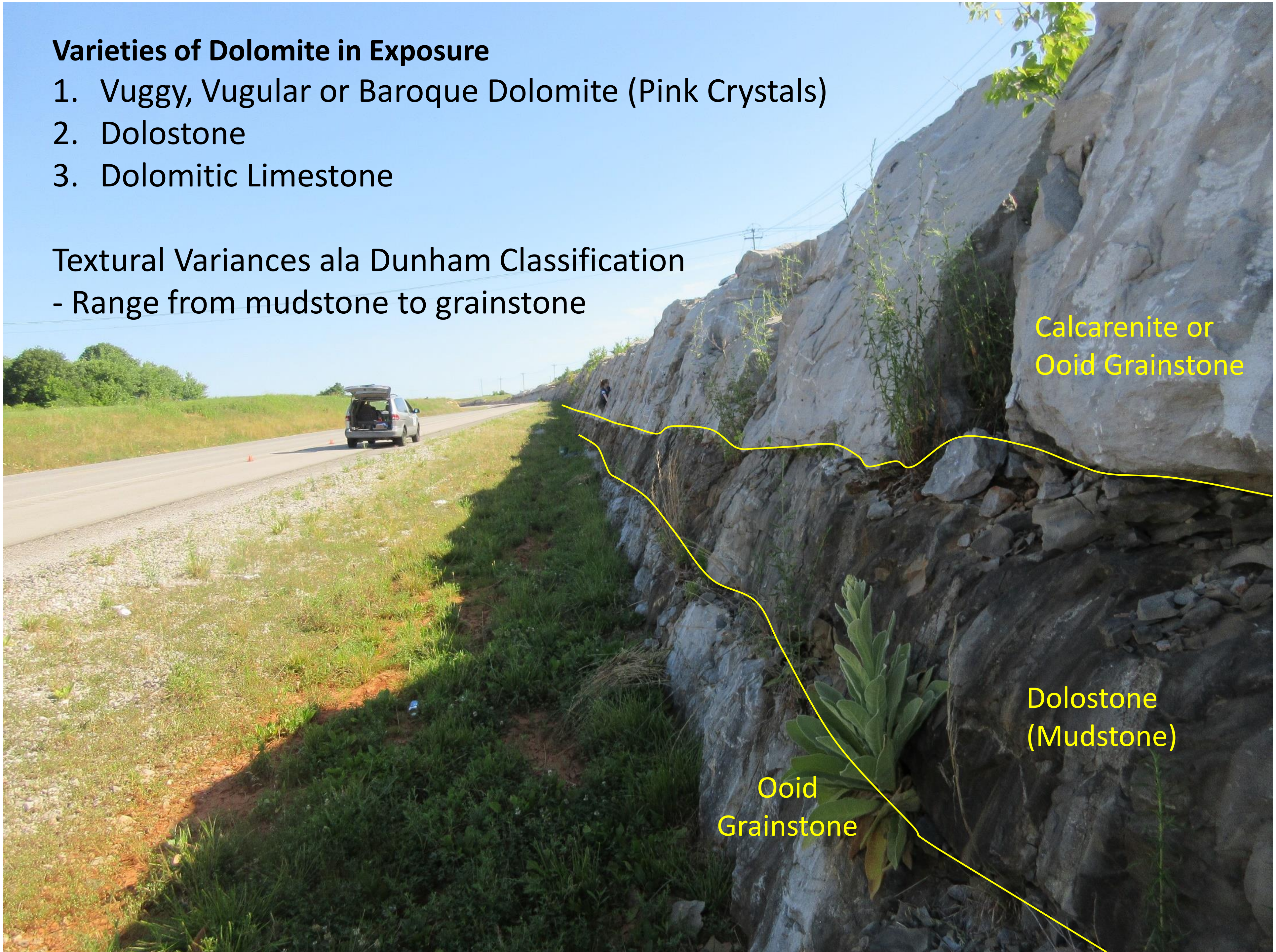
Geochemical & fluid inclusion data (Spotl & Pitman, 1998), in conjunction with mineral paragenetic info. suggest *saddle dolomite* is a reliable indicator of rock–brine interactions at Temp. that coincide largely with the liquid hydrocarbon ‘window’ & extend well into dry gas zone.

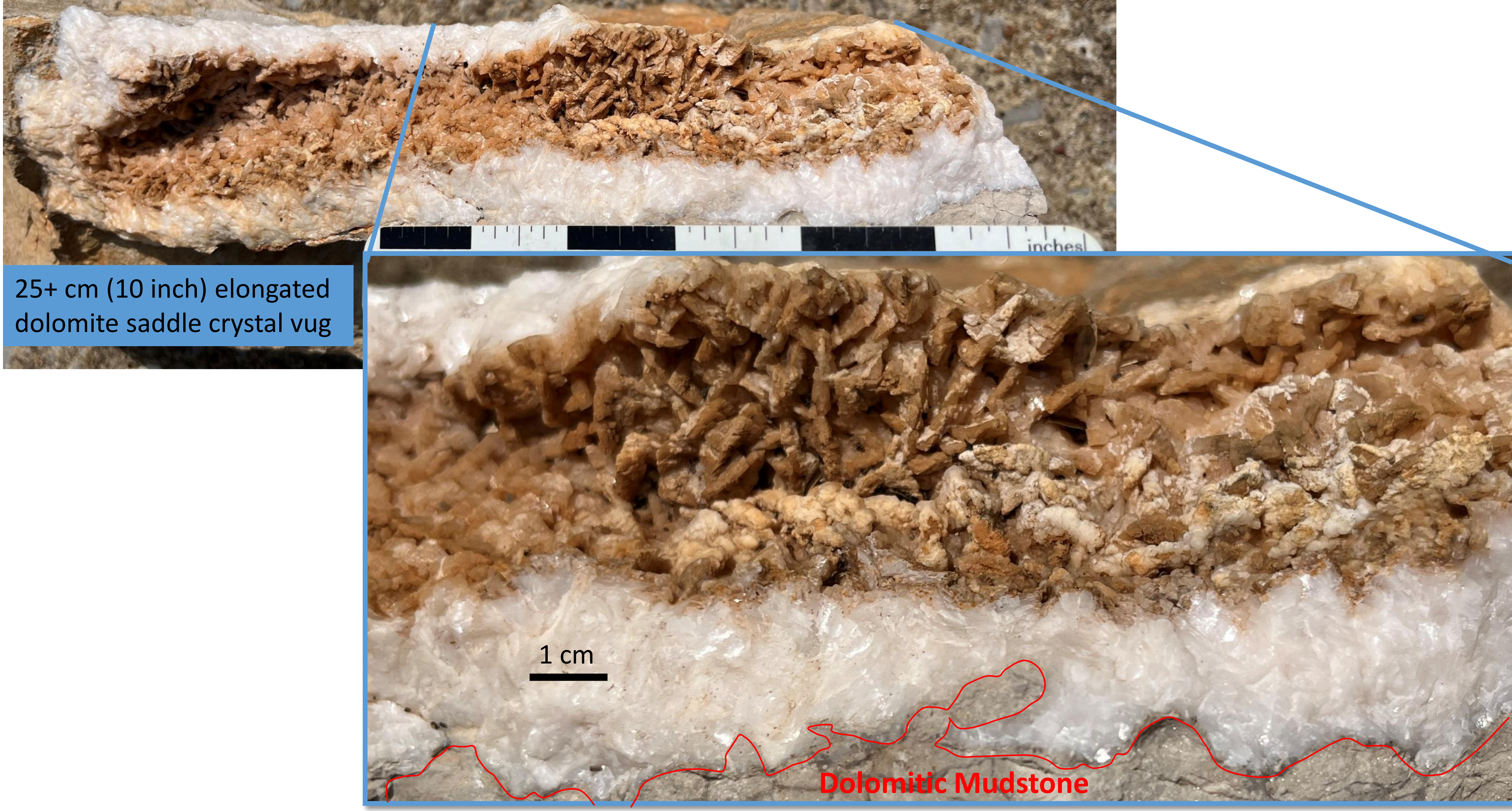
Varieties of Dolomite in Exposure

1. Vuggy, Vugular or Baroque Dolomite (Pink Crystals)
2. Dolostone
3. Dolomitic Limestone

Textural Variances ala Dunham Classification

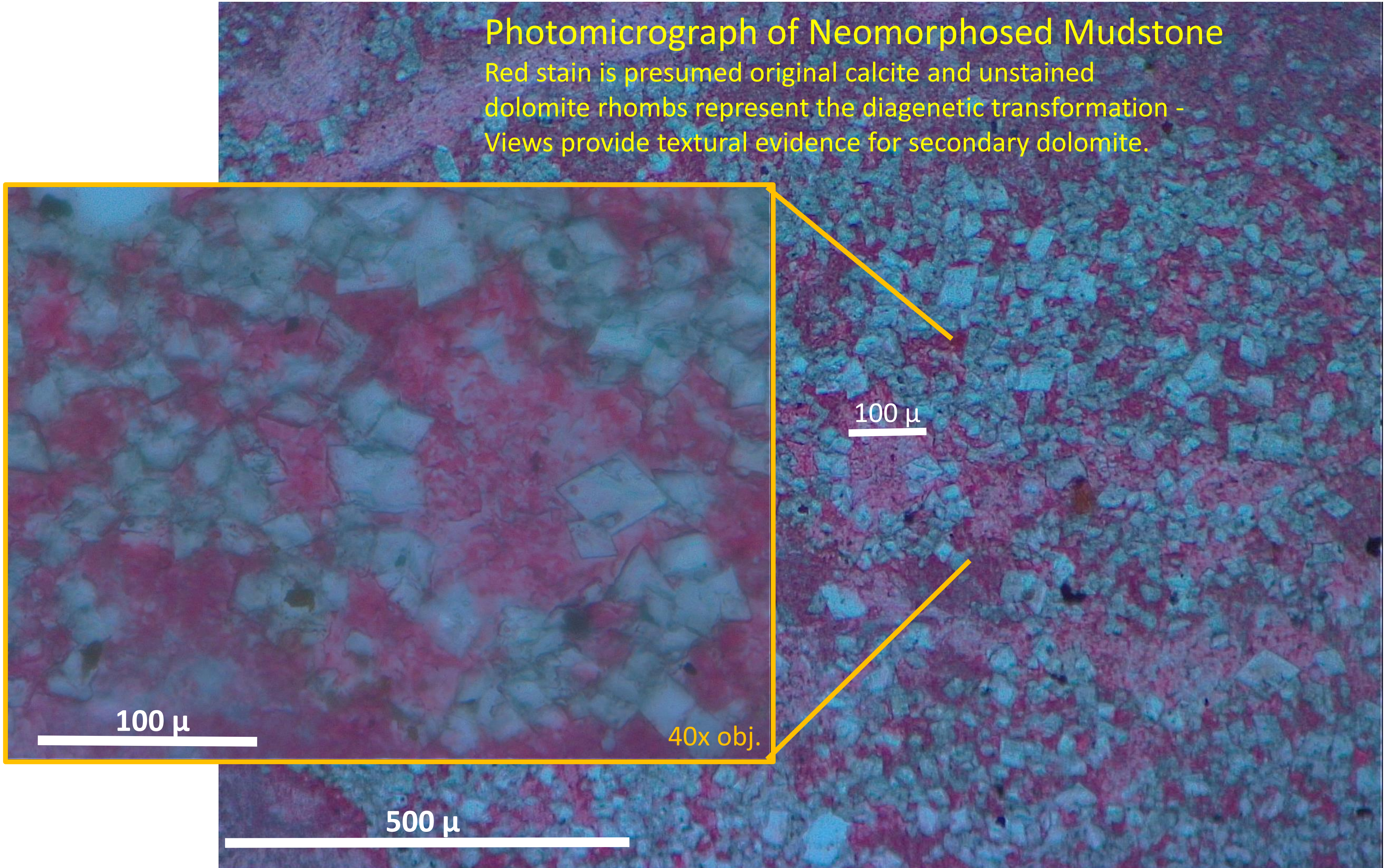
- Range from mudstone to grainstone

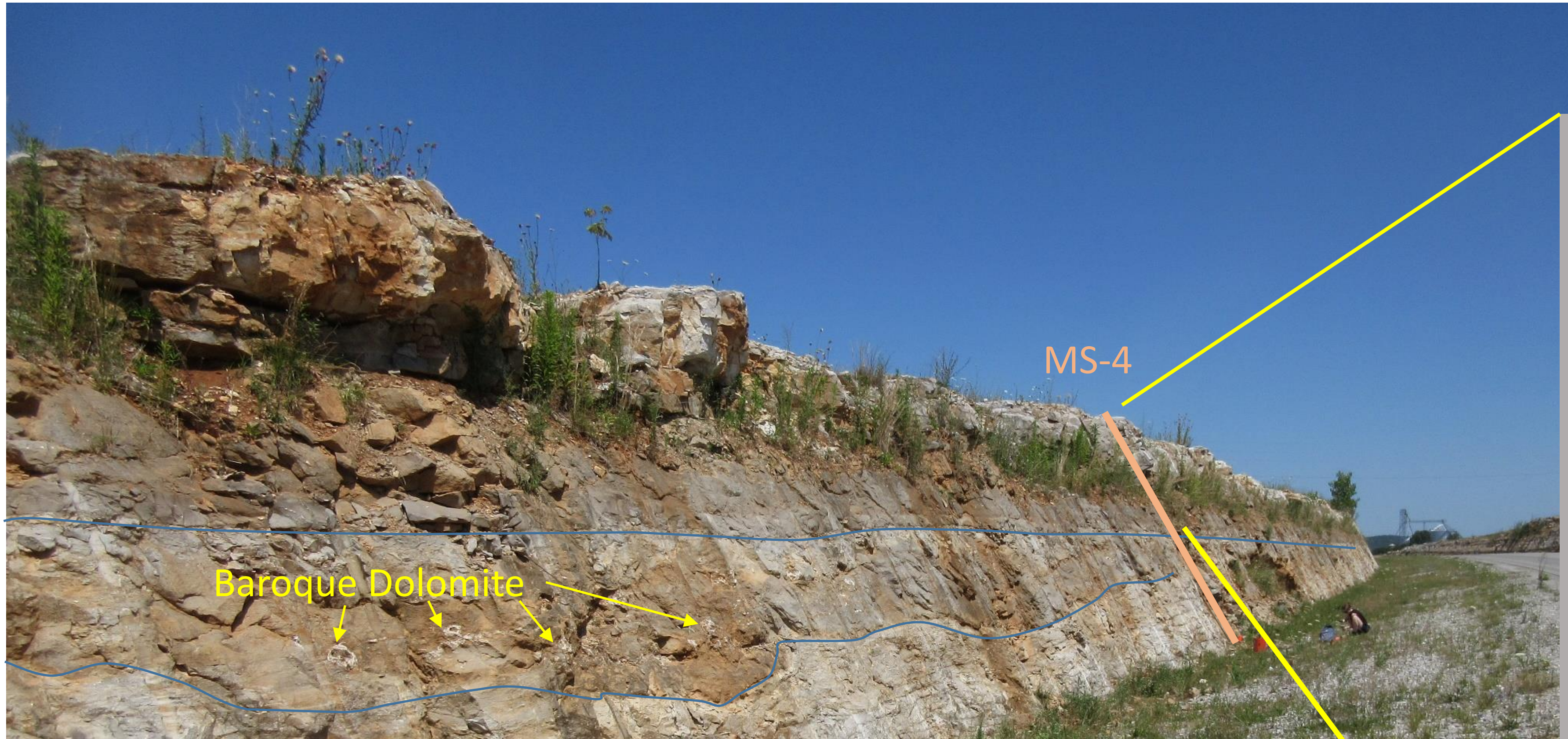




25+ cm (10 inch) elongated dolomite saddle crystal vug


inches
y for Sedimentary Geology
www.sepm.org
centimeters
Acid etched – pits
are calcitic areas
in otherwise dolostone
(neomorphosed mudstone)


Photomicrograph of Neomorphosed Mudstone
Red stain is presumed original calcite and unstained
dolomite rhombs represent the diagenetic transformation -
Views provide textural evidence for secondary dolomite.
100 μ
100 μ
40x obj.
500 μ



4-10 (16.5 - 17 ft.) → dry 10YR 7/1 - 7/2 (light gray), wet 10YR 6/2 (light brownish gray)
---ooid grainstone

4-9 (15.5 - 16.5 ft.) → dry 7.5YR 7/2 (pinkish gray), wet 10YR 7/2 (ight gray)
---ooid grainstone

4-8 (15 - 15.5 ft.) → dry 10YR 7/1, (light gray) wet 10YR 6/2 -7/2 (light brownish gray-light gray)
---ooid grainstone

4-7 (14.5 - 15 ft.) → dry 10YR 7/1 (light gray) , wet 10YR 7/2 (light gray)
--- base cemented, grades from grainy to muddy upward (fining)

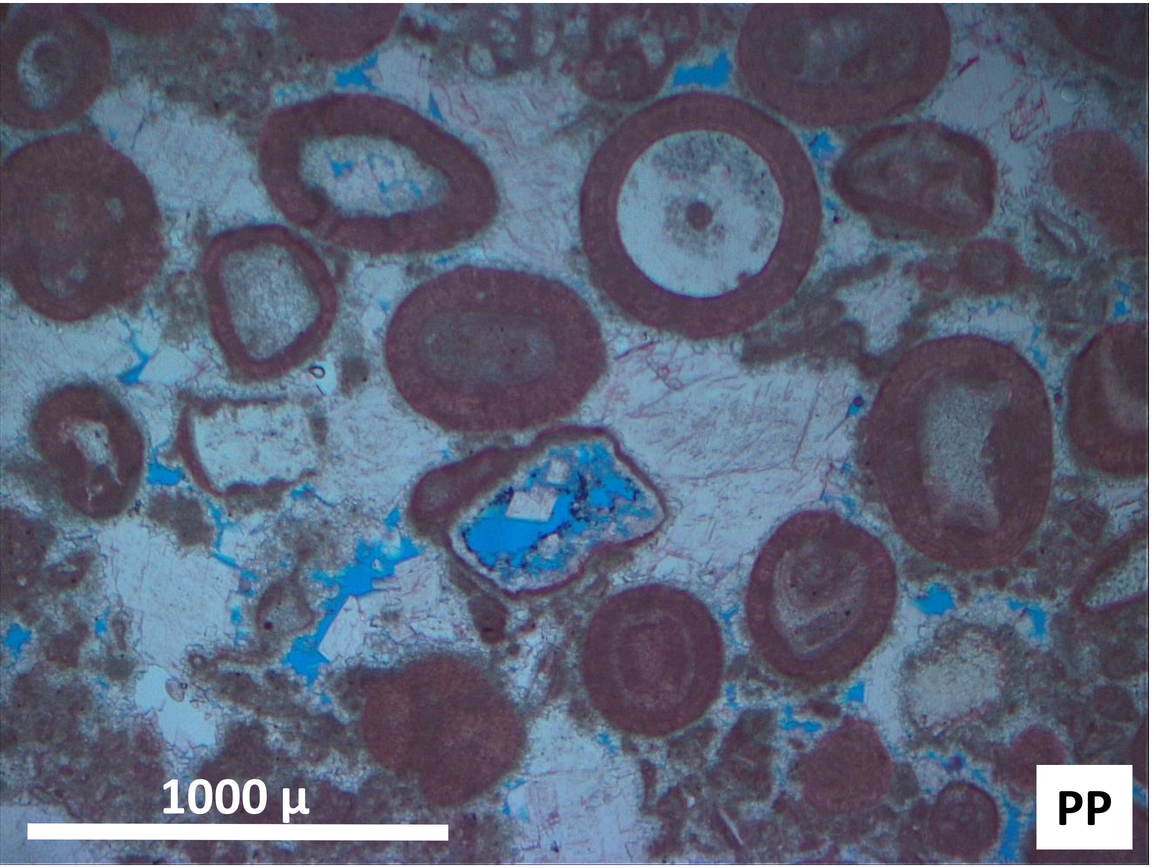
4-6 (13.5 -14 ft.) →dry 10YR 7/1 -7/2, (light gray), wet 10YR 6/2-6/3 (light brownish gray – pale brown)
---ooid grainstone, stylolites

4-5 (13 - 13.5 ft.) → dry 10YR 7/1 (light gray) wet 10YR 6/1 - 6/2 6/2 (gray – light brownish gray)
--- ooid grainstone

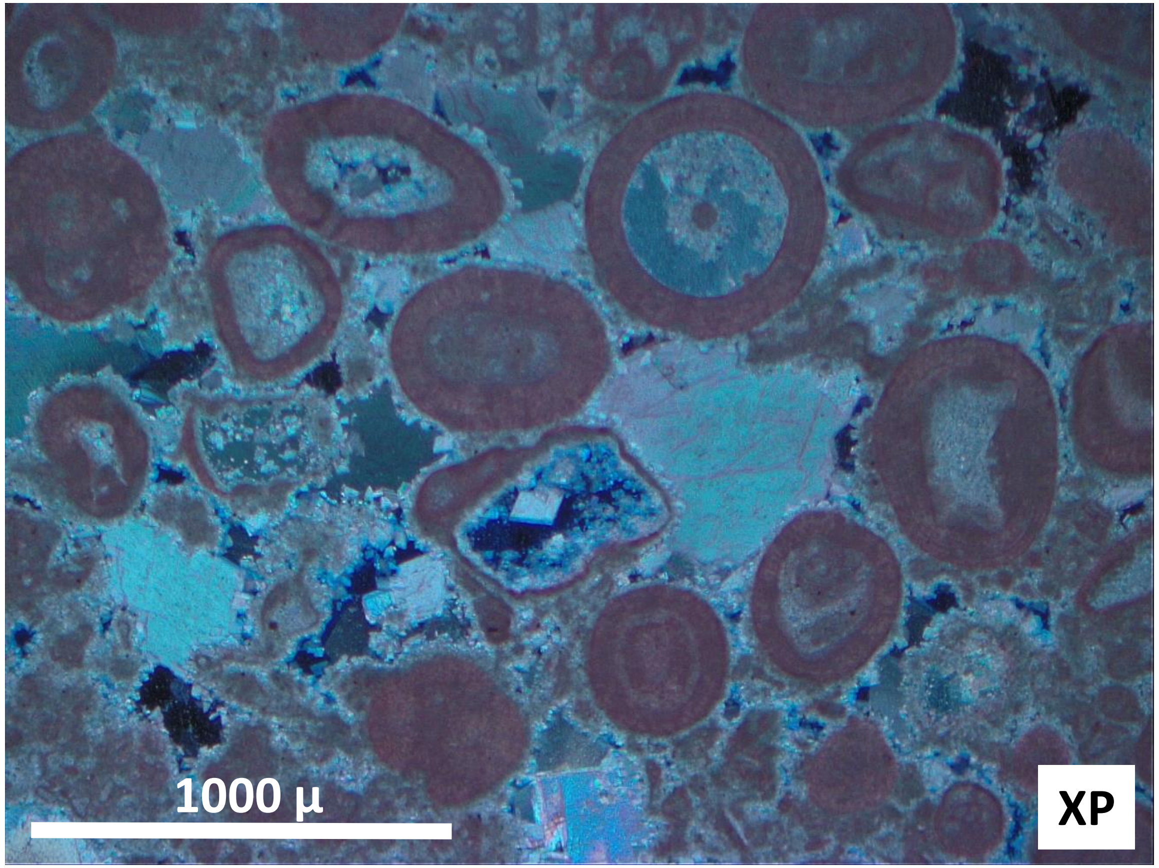
4-4 (12 - 12.5 ft.) → dry 10YR 6/1 - 7/1 (gray –light gray), wet 10YR 4/2 -5/2 (dark grayish brown –grayish brown)
---dolomitic mudstone/wackestone
---dolomite is very burrowed

Select Samples uppermost 5 feet

Insular Limestone fragments or breccia associated with vuggy dolomite in ooid grainstone.



3-1c-1-PP 001



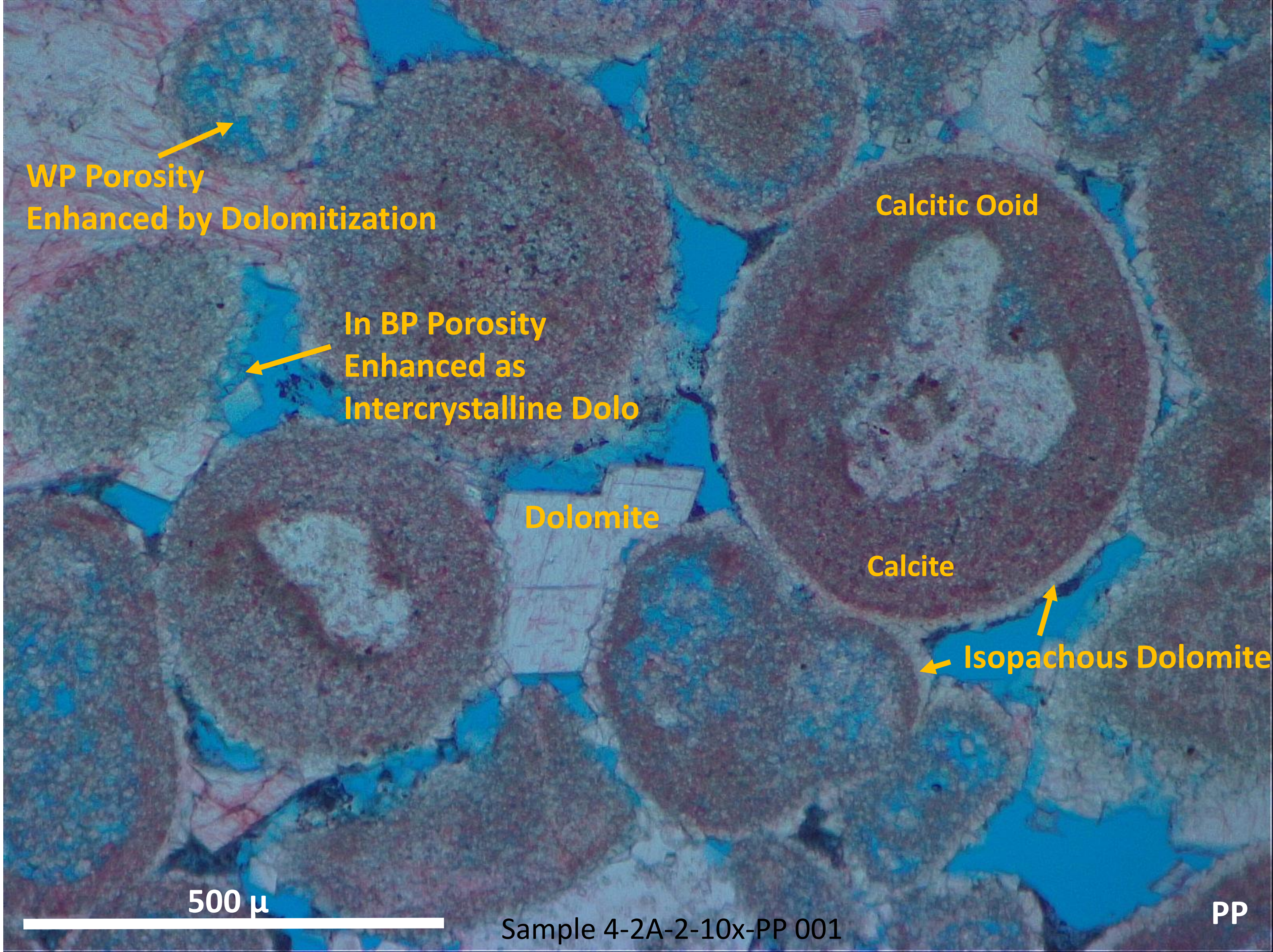
3-1c-1-XP 001

Ooid Grainstone with Extensive Dolomitization – Note WP Porosity Development And BP Porosity occlusion

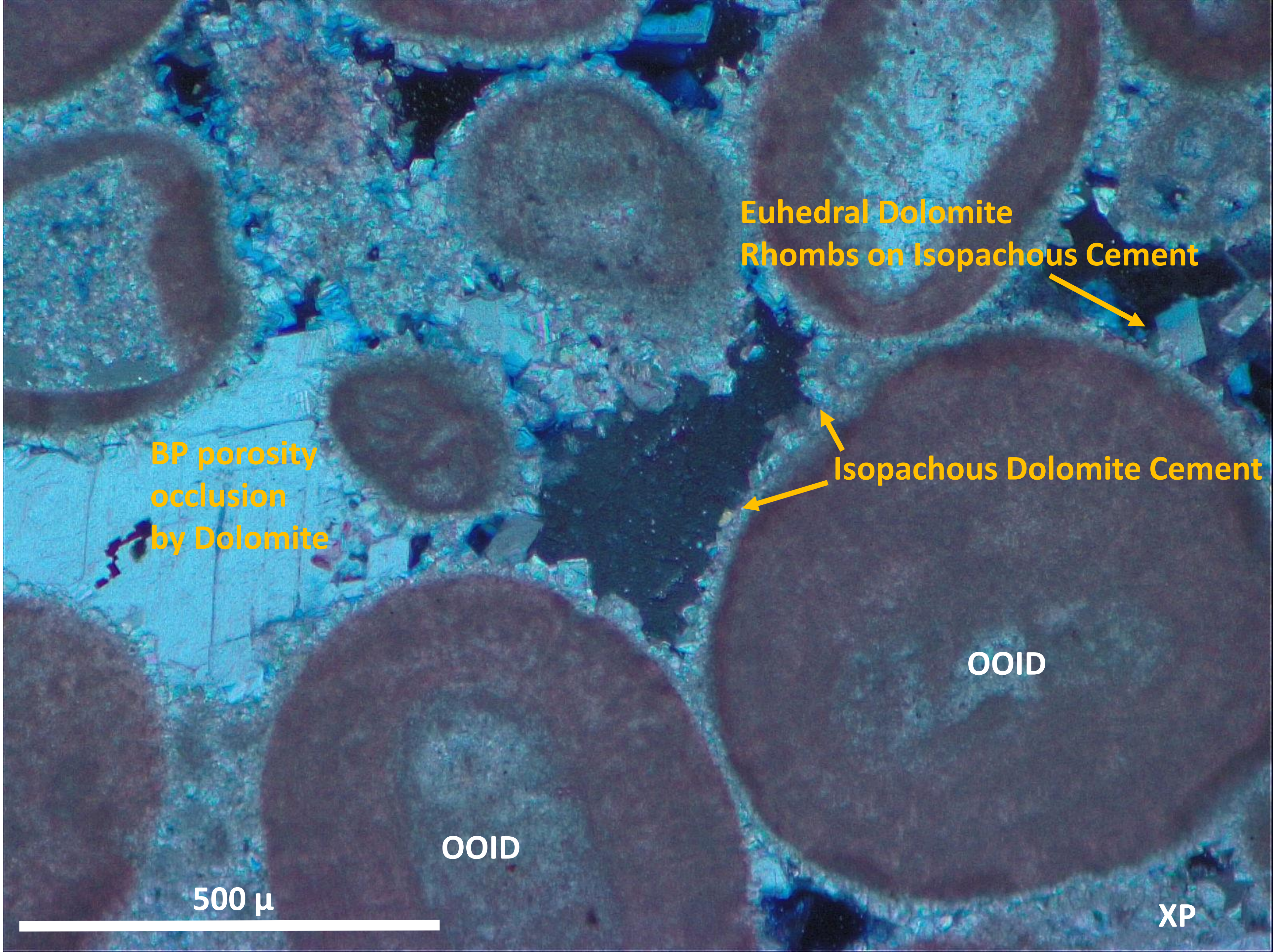
Ooid Grainstone with Herringbone (Bidirectional) crossbeds
-Devoid of vuggy dolomite at this particular location; Lower portion of the west side of road cut

Note Dolomitization increased porosity:

- Intercrystalline,
- WP (dolo. replaced calc. in ooids),
- BP – thin isopachous dolomite,
- Significant BP porosity



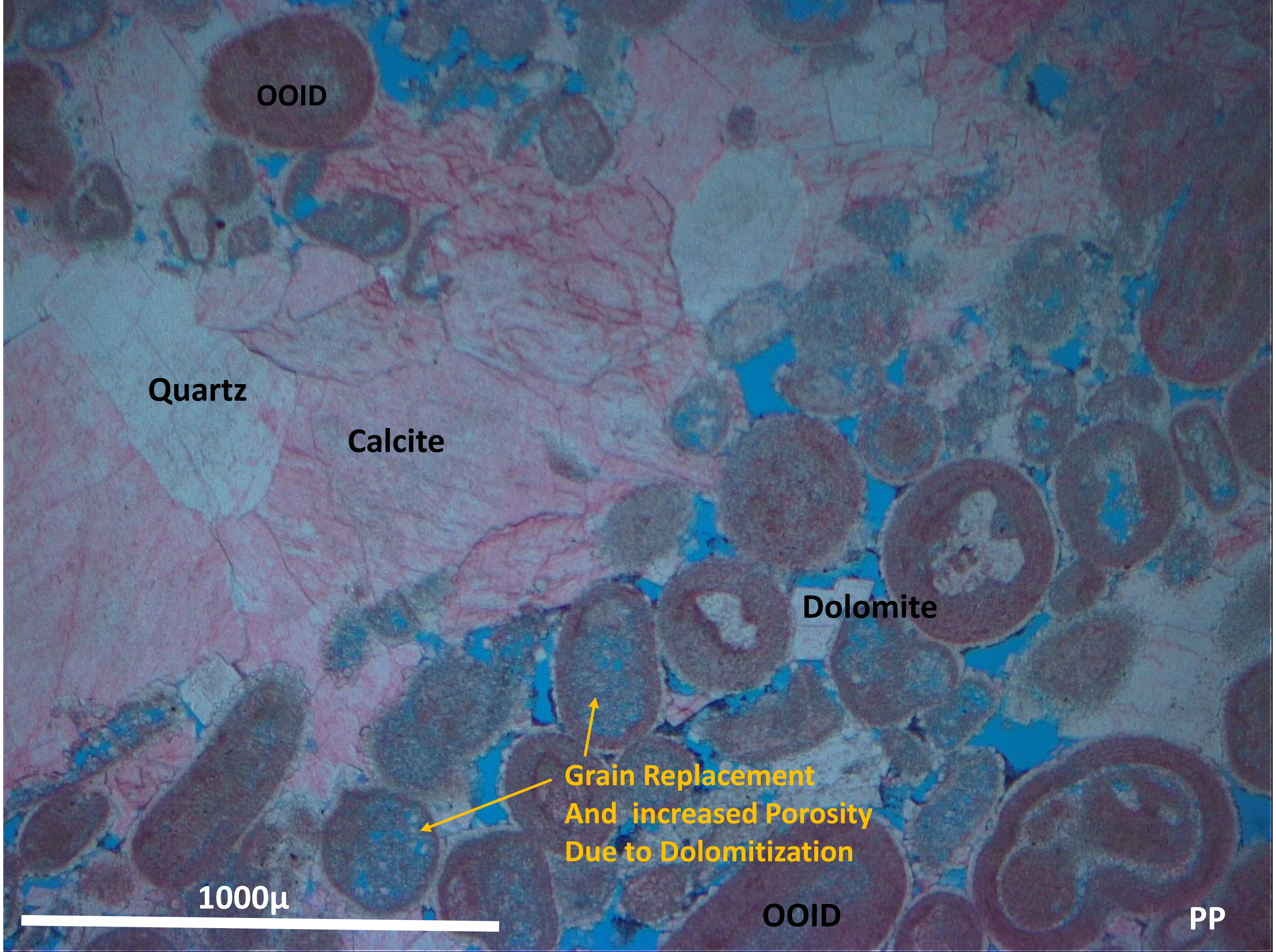
3-1c-4-10x-XP



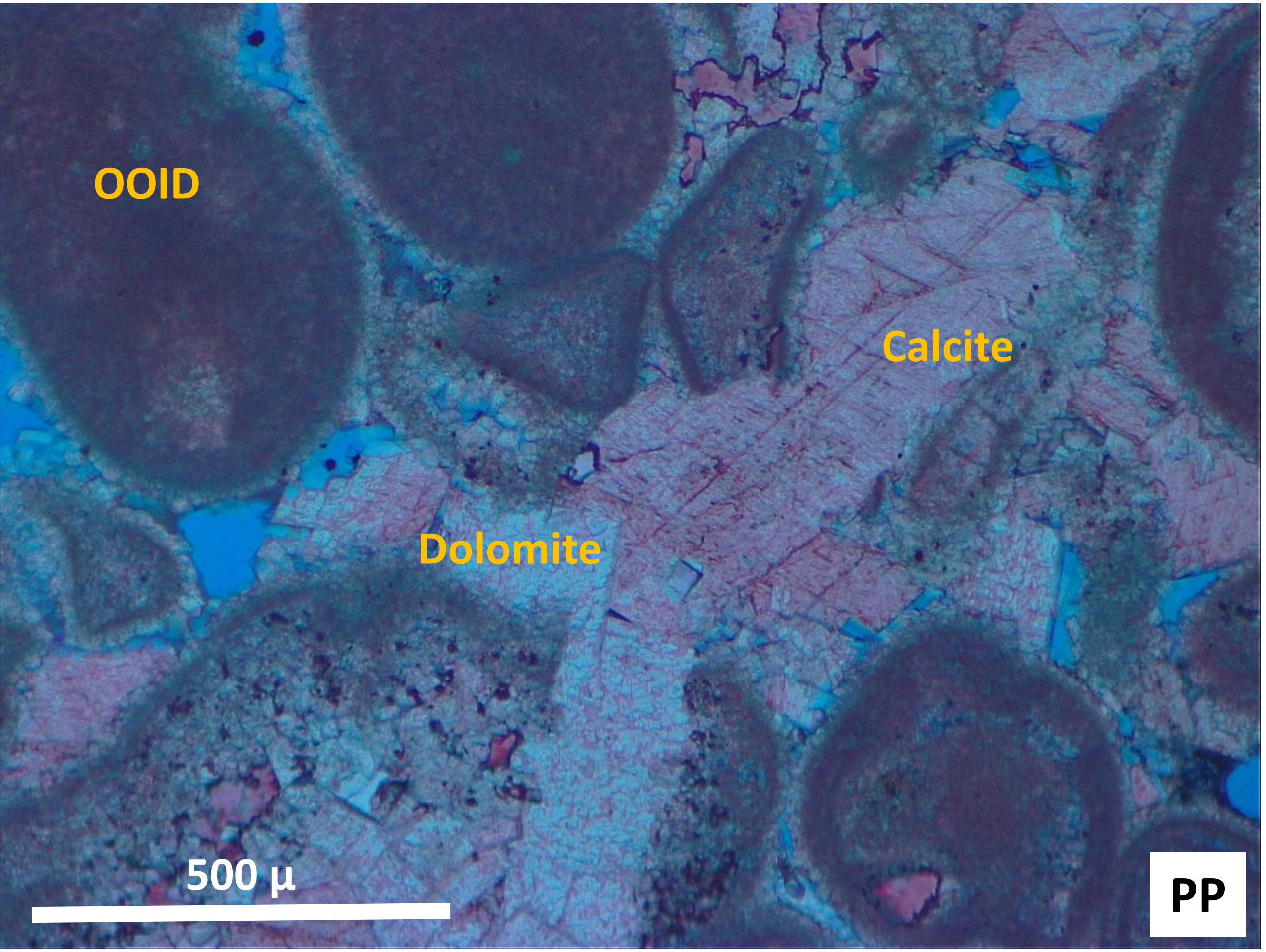
Euhedral Dolomite
Rhombs on Isopachous Cement
BP porosity
occlusion
by Dolomite
Isopachous Dolomite Cement
OOID
OOID
500 µ
XP

Joints or Fractures obliquely to vertically cutting bedding – the only significant mineral is calcite -east side of cut

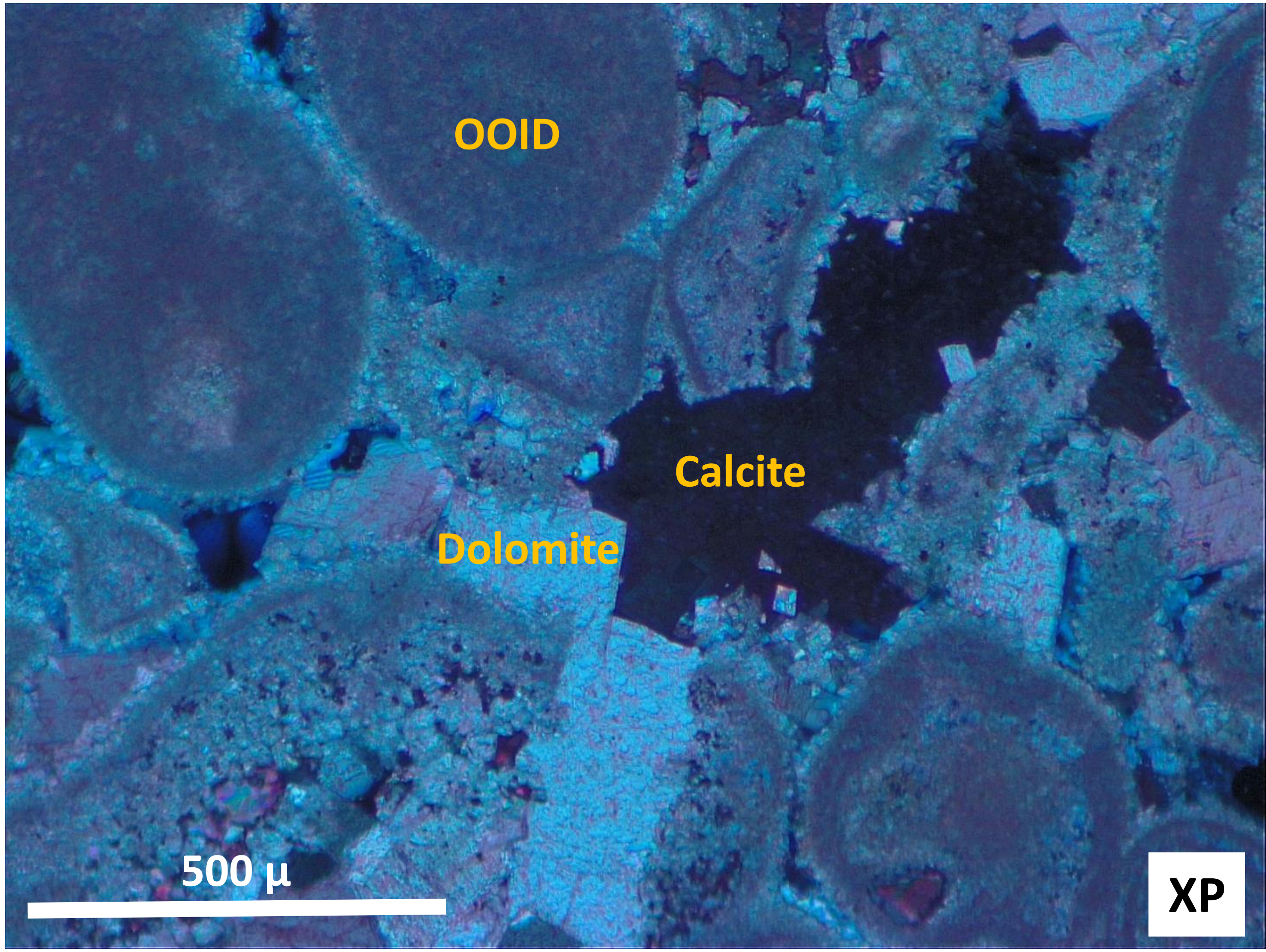
Hammer for scale



4-2A-1-4X-PP 001

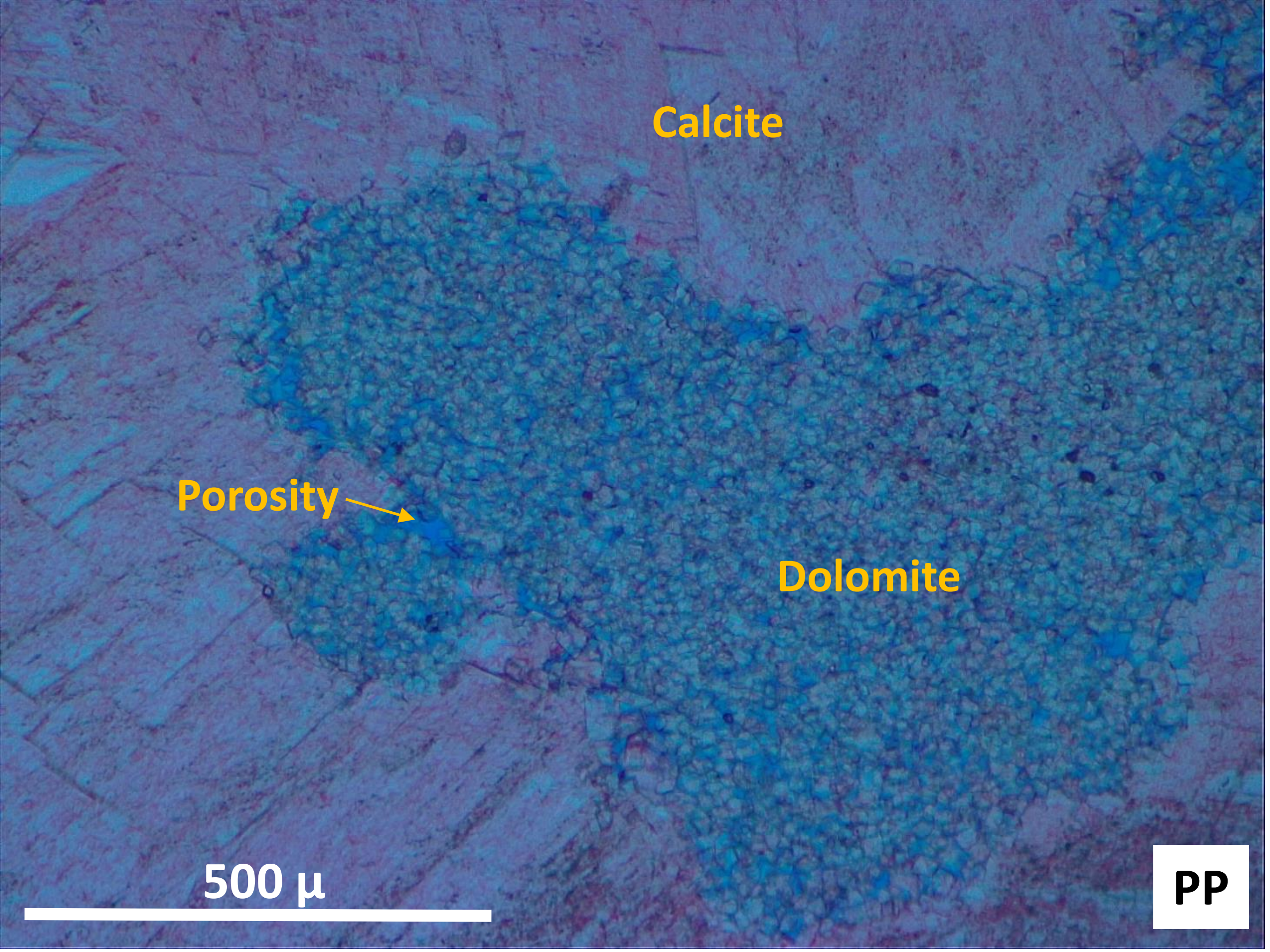


4-2b-2-10x-PP

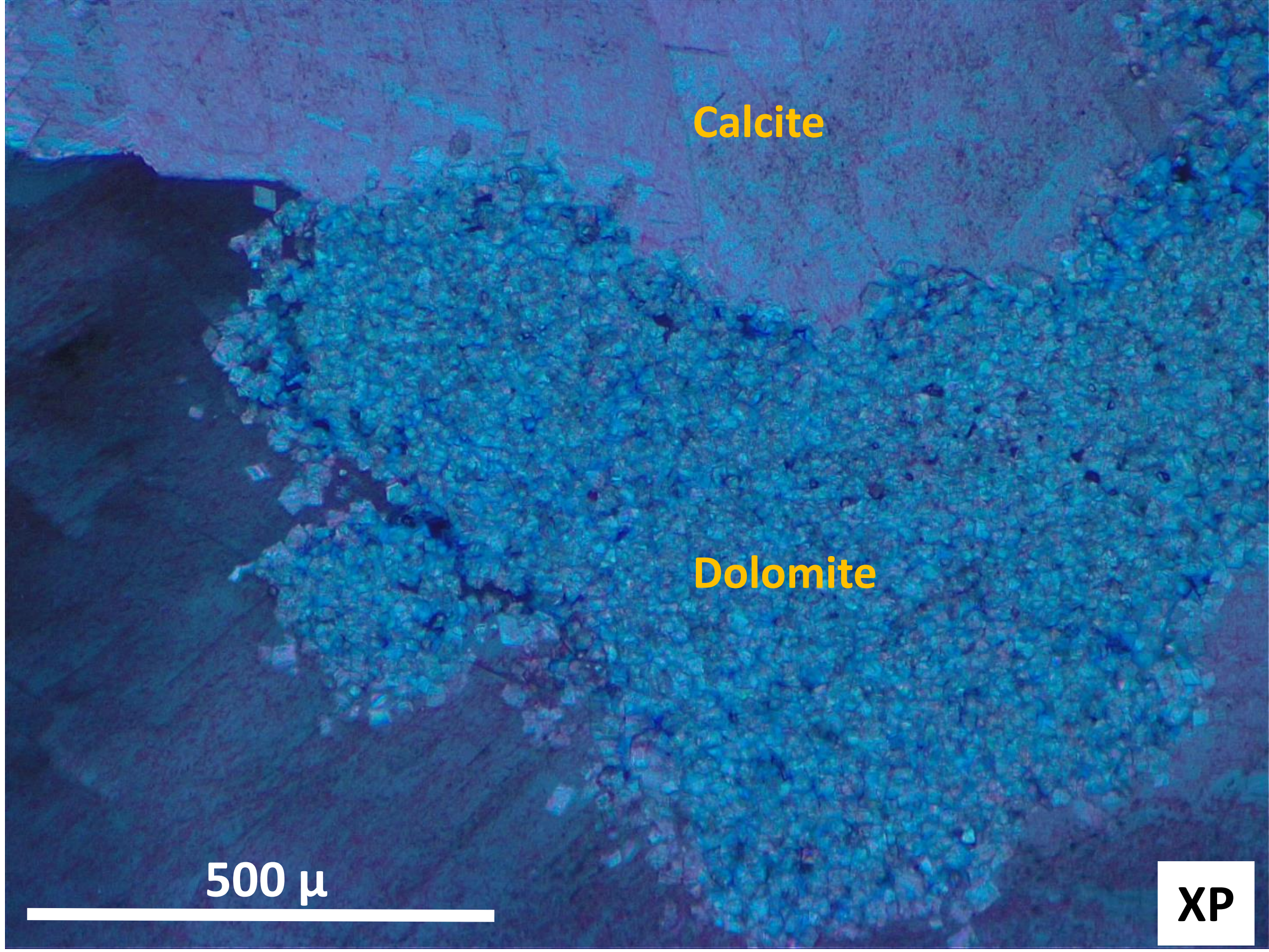


4-2b-2-10x-XP

Intergrowths of dolomite & calcite - note staining demarcating this



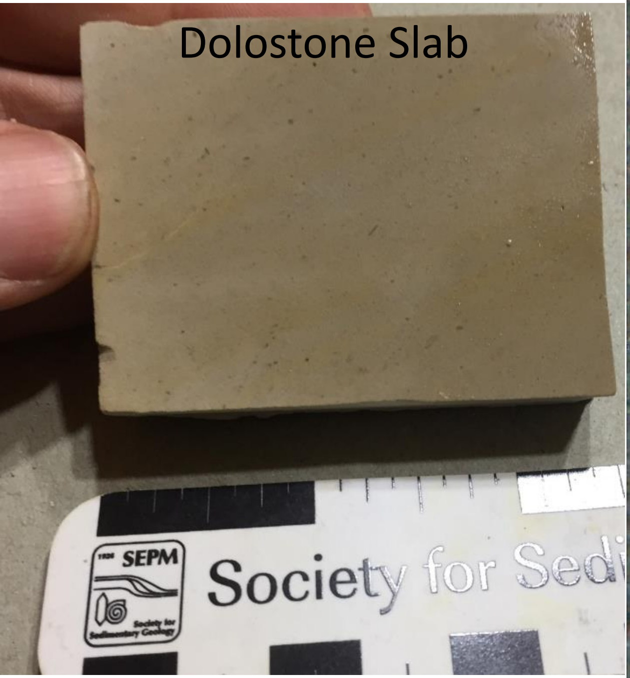
MS4-FL-3-10x-PP



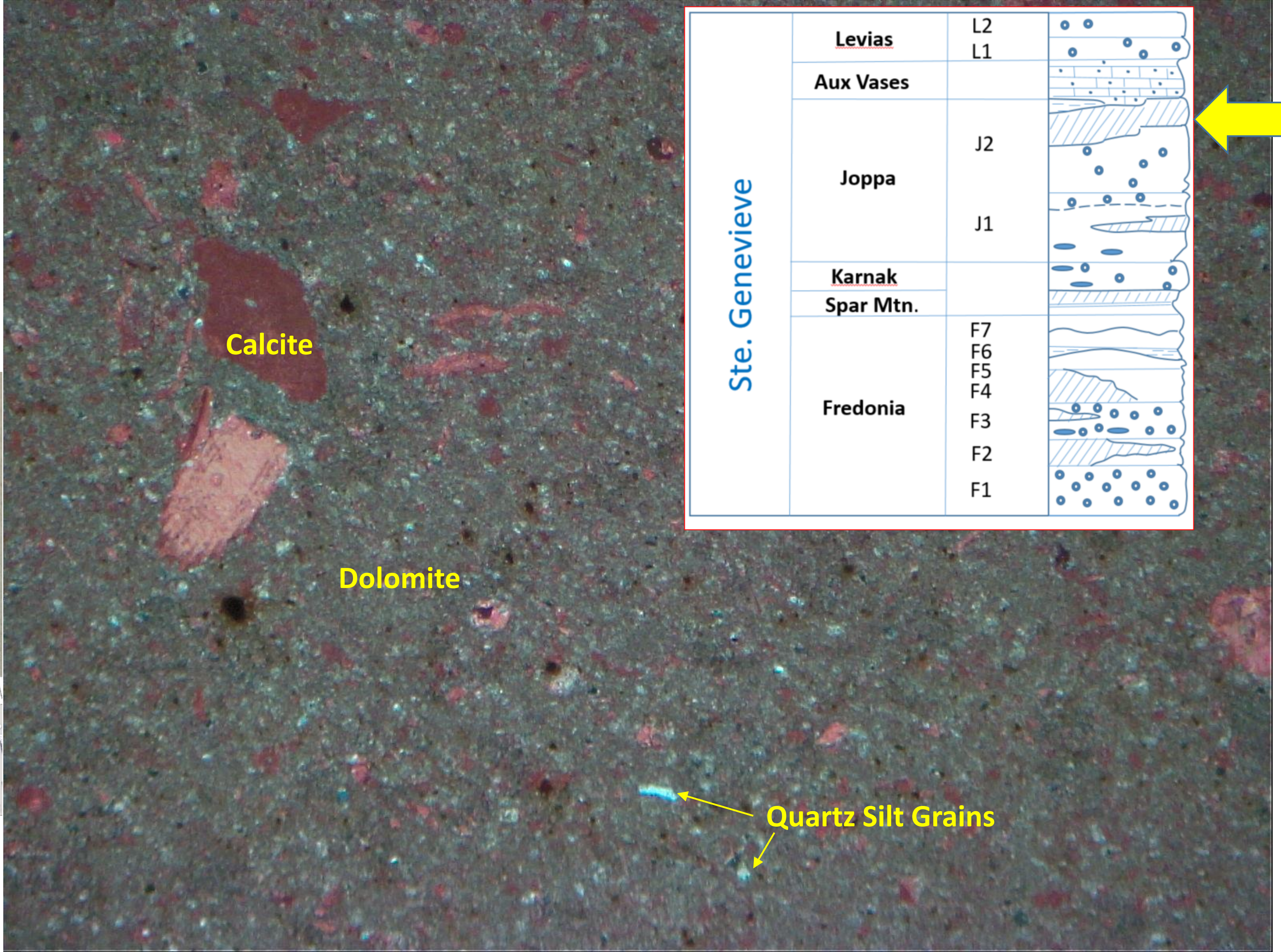
MS4-FL-3-10x-XP

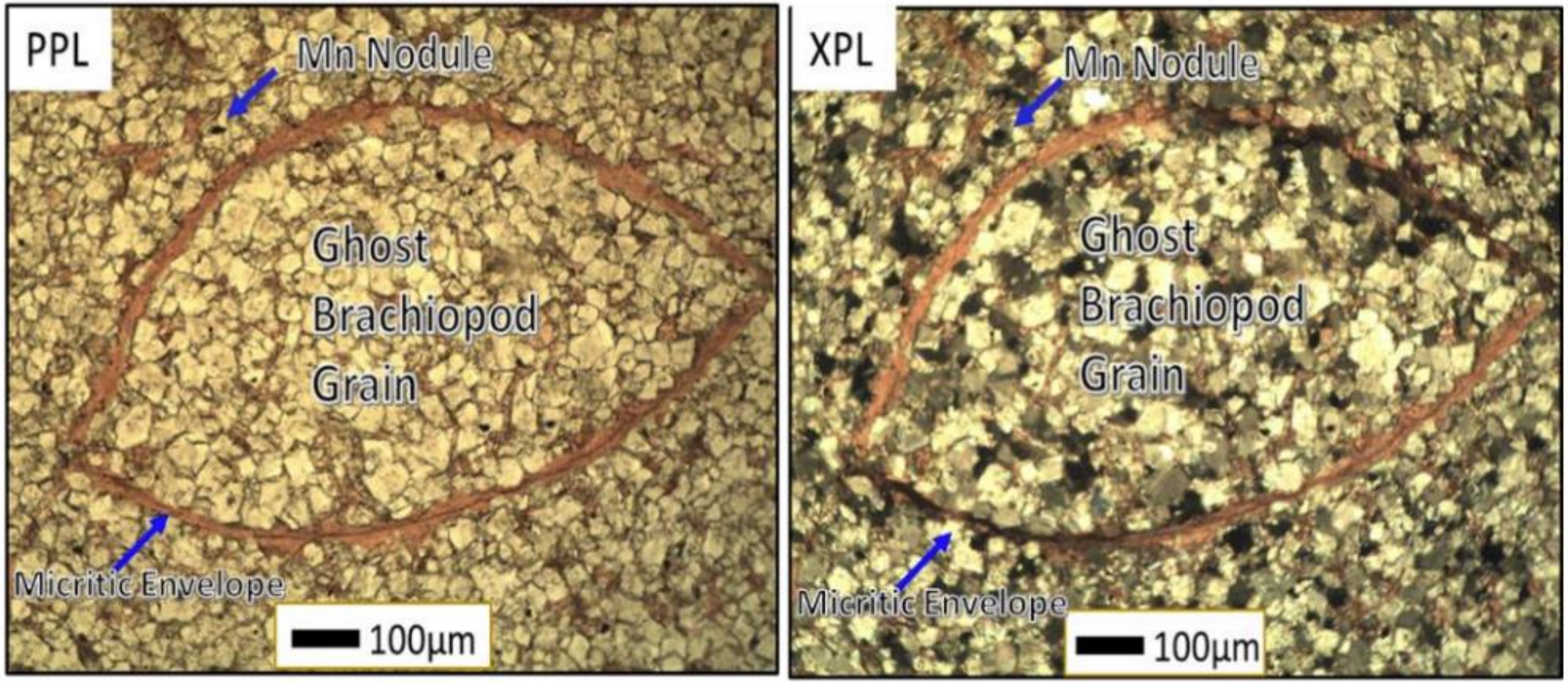
Typical microporosity (intercrystalline porosity) developed in dolomitized zones

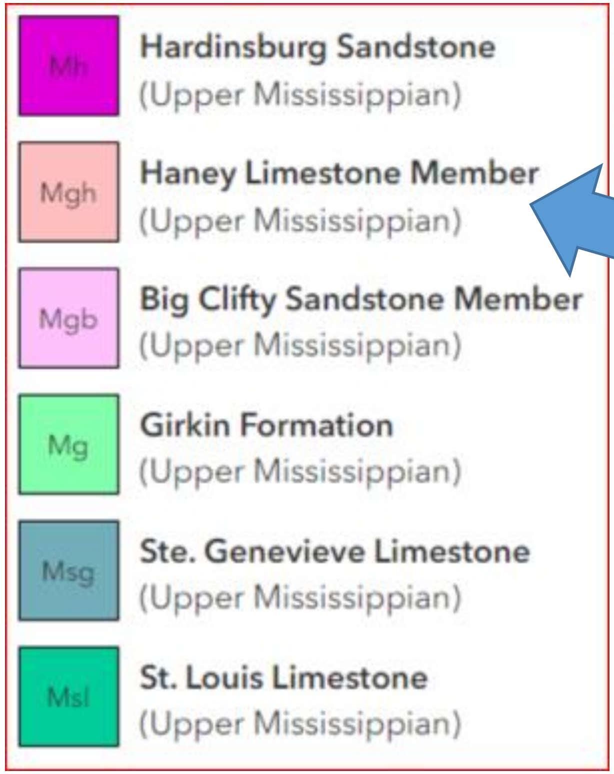
Alizarin Red S staining shows calcitic grain in Ste Gene with primarily nonstained muddy “matrix” primarily dolomite. Minor quartz silt grains also present.



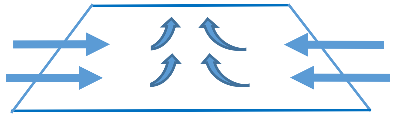
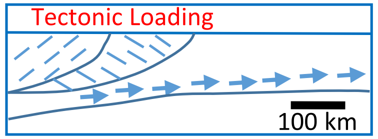
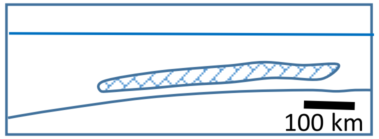
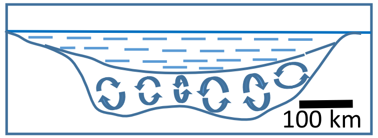
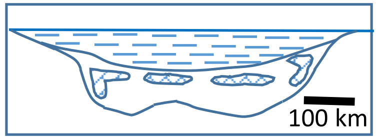
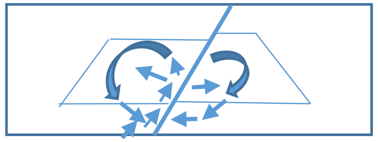
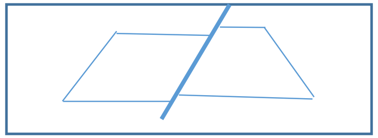
Sample C9 –MACA Mammoth Cave







Haney Limestone
Dolomitization
From Devine (2016)
MS Thesis Western KY University

Dolomitization Model	Source of Mg^{2+}	Delivery Mechanism	Hydrologic Model	Predicted Dolomite Patterns
D1. Burial Dolomitization (local scale)	Basinal Shales	Compaction-Driven Flow		
D2. Burial Dolomitization (regional scale)	Various Subsurface Fluids	Tectonic Expulsion Topography-Driven Flow		
D3. Burial Dolomitization (regional scale)	Various Subsurface Fluids	Thermo-Density Convection		
D4. Burial Dolomitization (local & regional scale)	Various Subsurface Fluids	Tectonic Reactivation Of Faults (Seismic Pumping)		

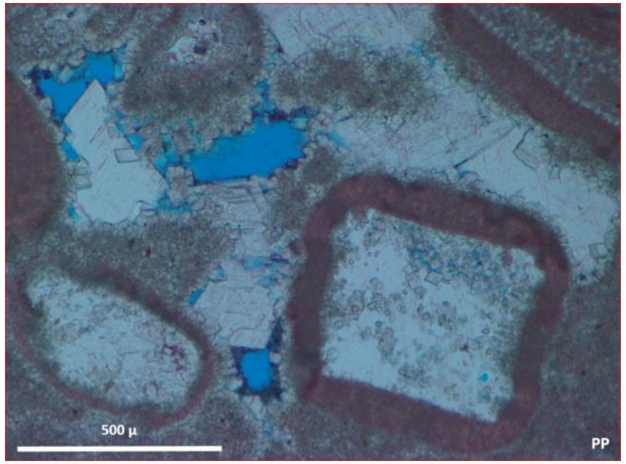
Burial Dolomitization Models considering Mg^{2+} source, Delivery mechanism, Hydrologic model & Predicted patterns (modified from Machel, 2005)

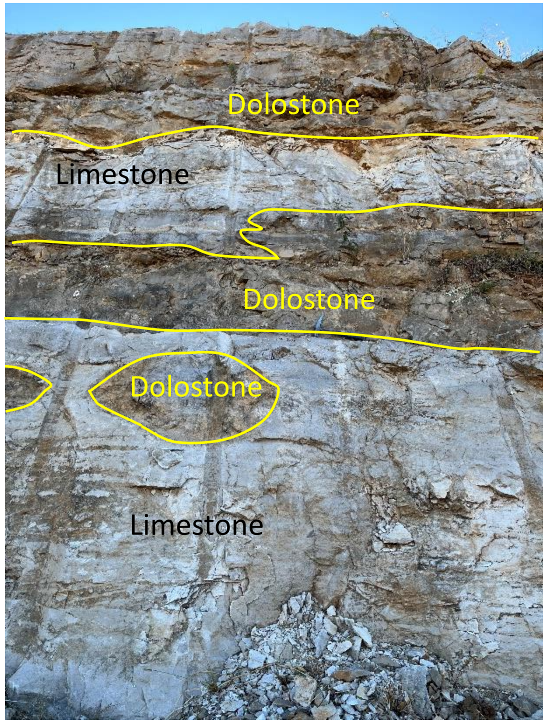
Conclusions

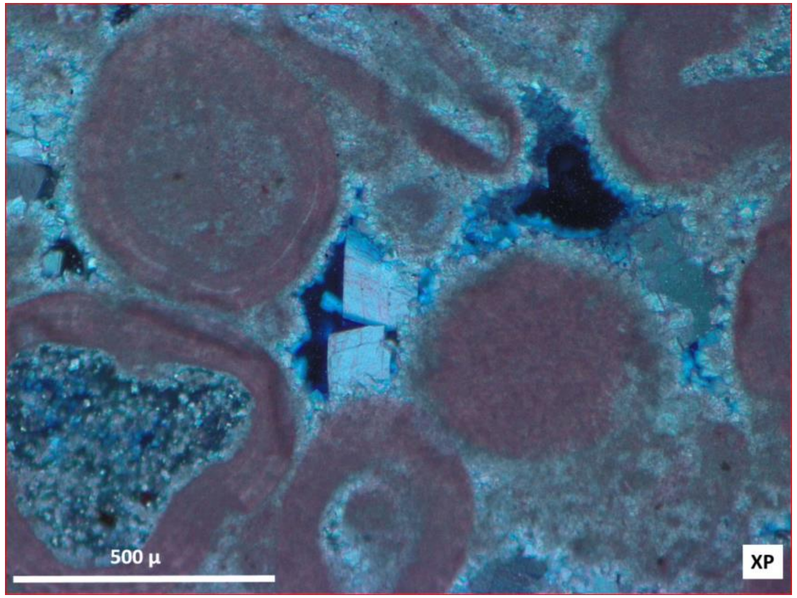
- Dolomite is present in all textures of carbonates deposited in a ramp setting ranging from muddy to grainy rocks in the exposed lower portion of the Fredonia Mbr. of the Ste Genevieve Limestone

- Dolomitization is commonly strata bound & mineralization generally follows bedding

- Bedding however itself has been altered by volumetric changes, formation of tears, and vugs, in general via dolomitization: crystal sizes range from micro (10s of microns) to large saddle crystals in vugs - many of which are elongated to bedding but some are nearly vertical; some near stylolite zones







Conclusions Continued & Future Work

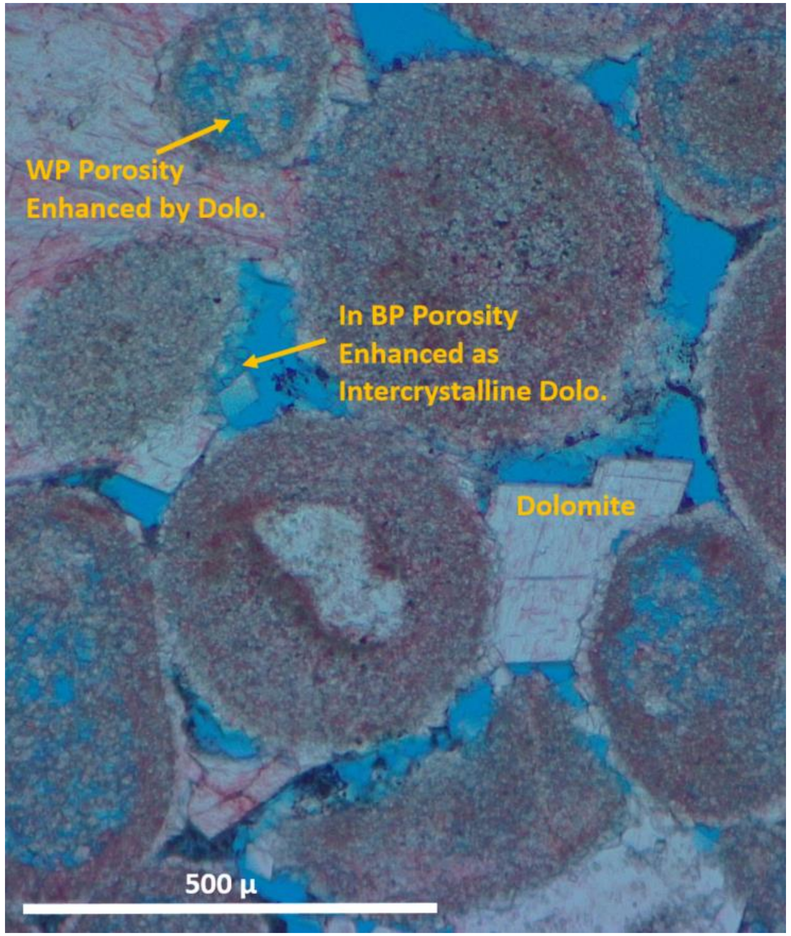
- ❑ Increase in effective porosity in WP and BP pores is markedly recognizable in petrographic study – implications for initiating some karst development in dolomitized zones (in Mammoth Cave – "sponge-like" dolomite in the Joppa 2 Mbr.)

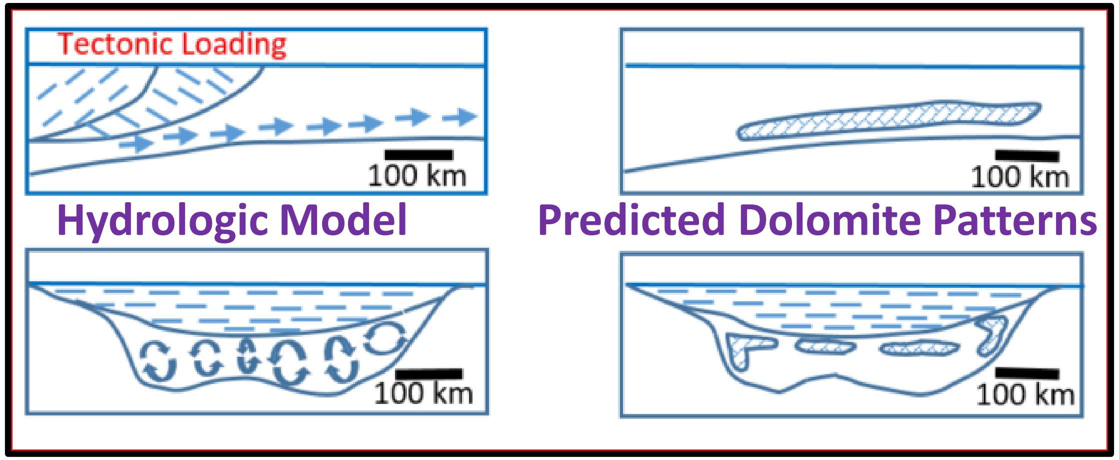
- ❑ Dolomitization models best explaining stratigraphic context of dolomite: tectonic expulsion and thermo-convection models based on stratigraphic and regional occurrences

- ❑ Faults down dip into the Illinois Basin apparently fed some mineralizing fluids with Mg^{2+}

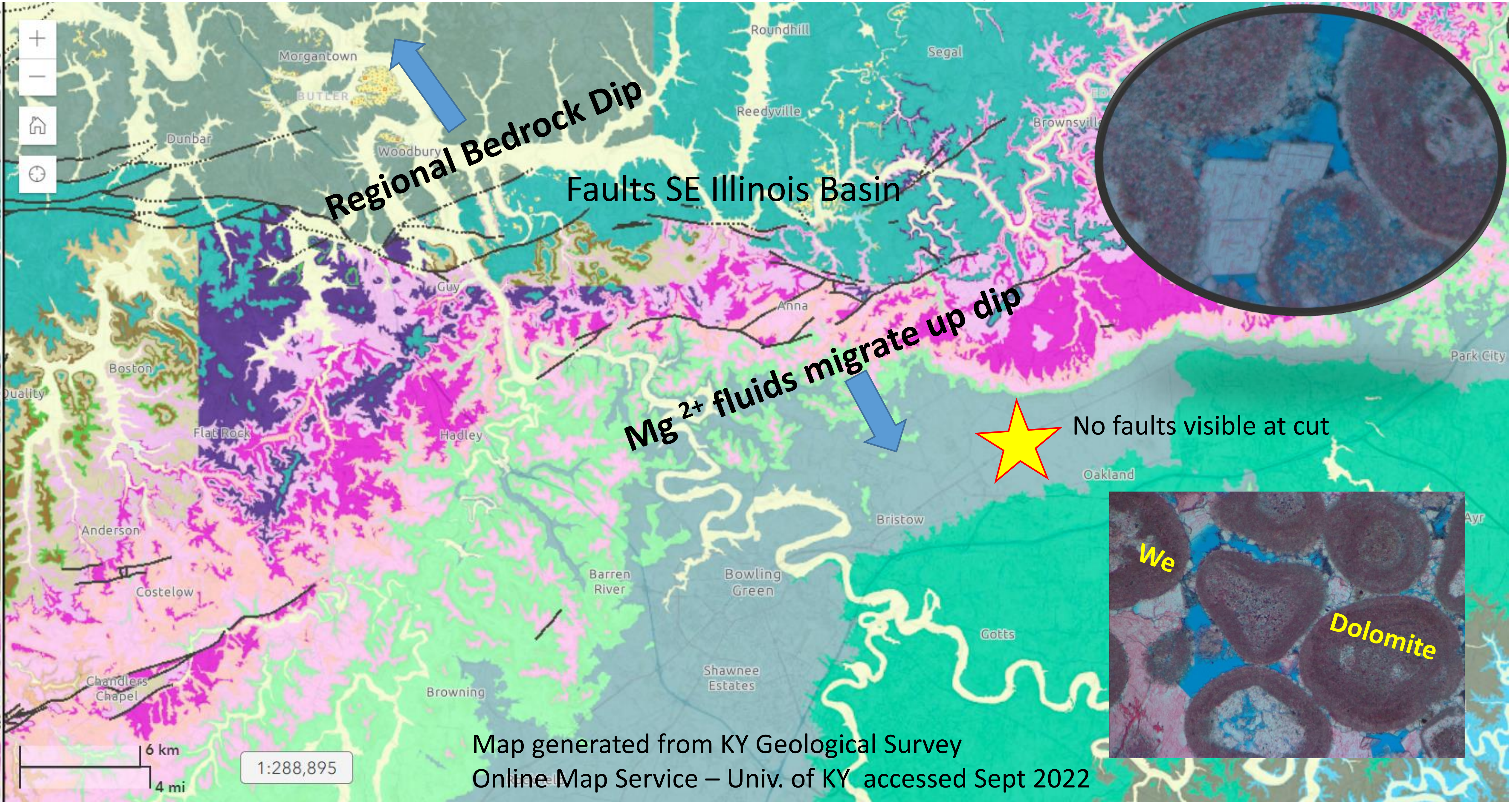
- ❑ Dolomite also associated with petroleum & asphalt rock resources – near Mammoth Cave & Bowling Green

- ❑ **Future work** – isotopic study to ascertain thermal history and potential sources for dolomitization





Conclusion -Source of Magnesium and Migration



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