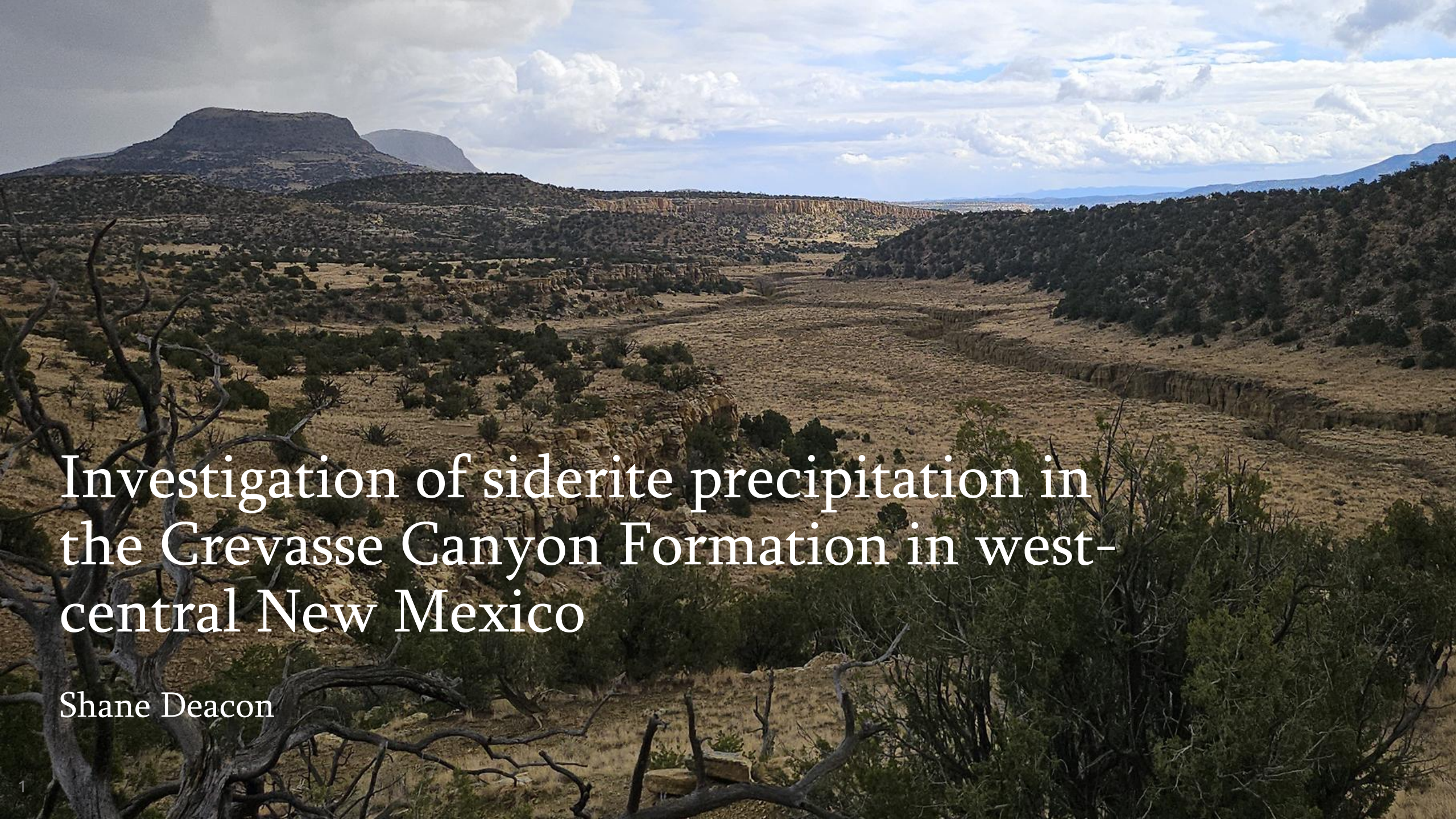


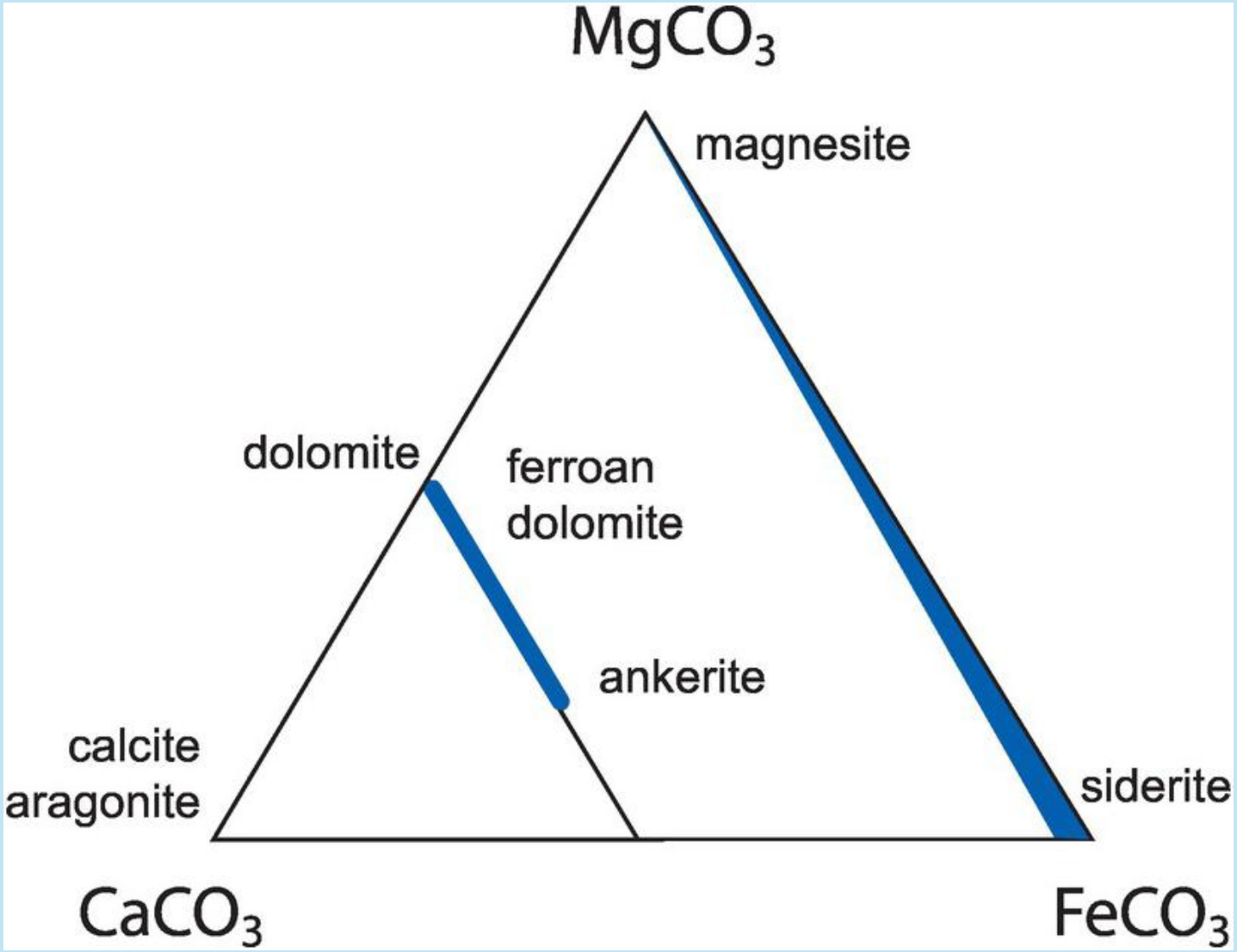
Investigation of siderite precipitation in the Crevasse Canyon Formation in west-central New Mexico

Shane Deacon

What is siderite?

- Iron carbonate ($FeCO_3$)
- Forms during diagenesis, and from reprecipitation[1,2]

(Rollinson and Pease, 2021)



1: Konrad- Schmolke et al., 2018
2: Macías and Camps-Arbestain, 2020

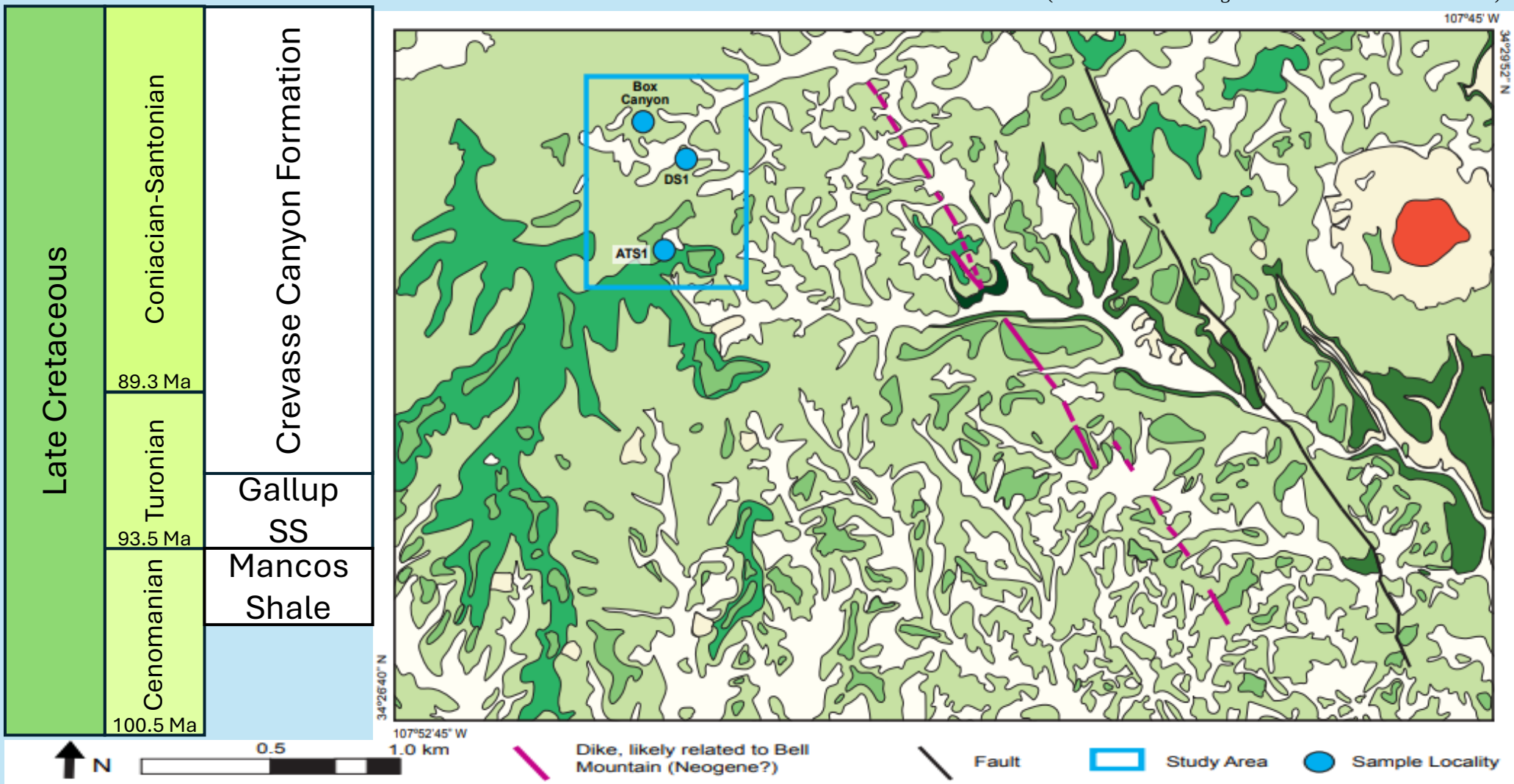
Goals of the Study

- Detailed petrographic analysis of the fine-grained sedimentary rocks of the Crevasse Canyon Formation
- Determine if the textural differences in hand sample and microscopic scales coincide with composition
- Identify the sedimentary and diagenetic environments causing siderite and calcite precipitation
- Co-precipitation vs multi-stage precipitation event of siderite and calcite

Crevasse Canyon Formation (Kcc)

(Modified from Lichtig and Lucas 2016 and Osburn1983)

- Turonian - Santonian
- Fluvial and deltaic deposition styles[5]
- Hydrocarbon systems
  - Splays
- Abundance of plant fossils



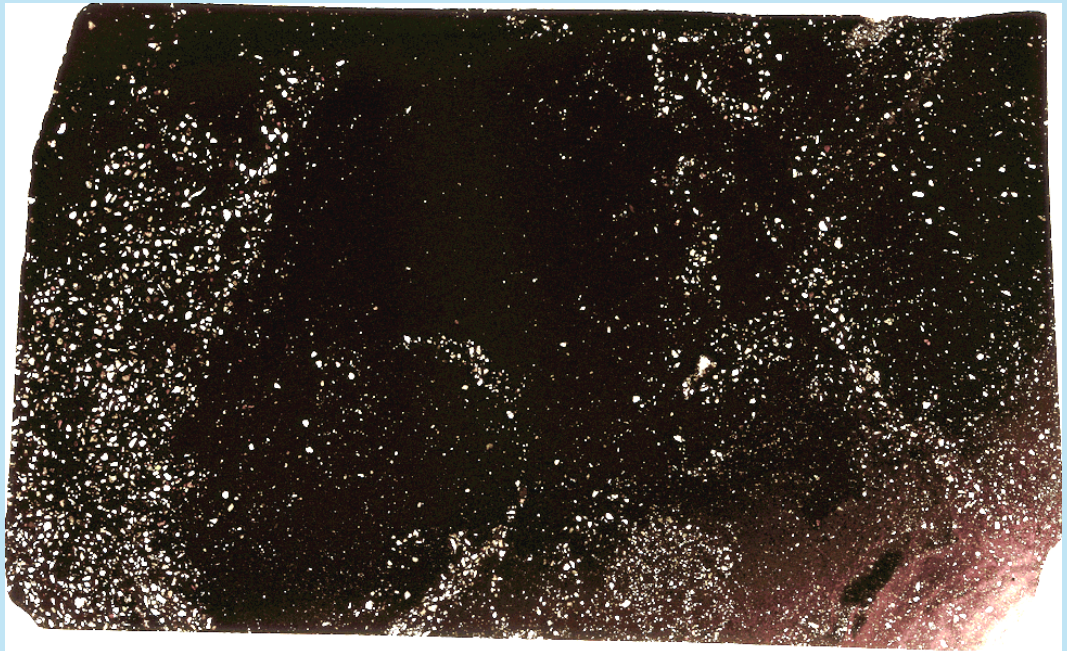
5: Johansen, 1983

Modes of Siderite Precipitation

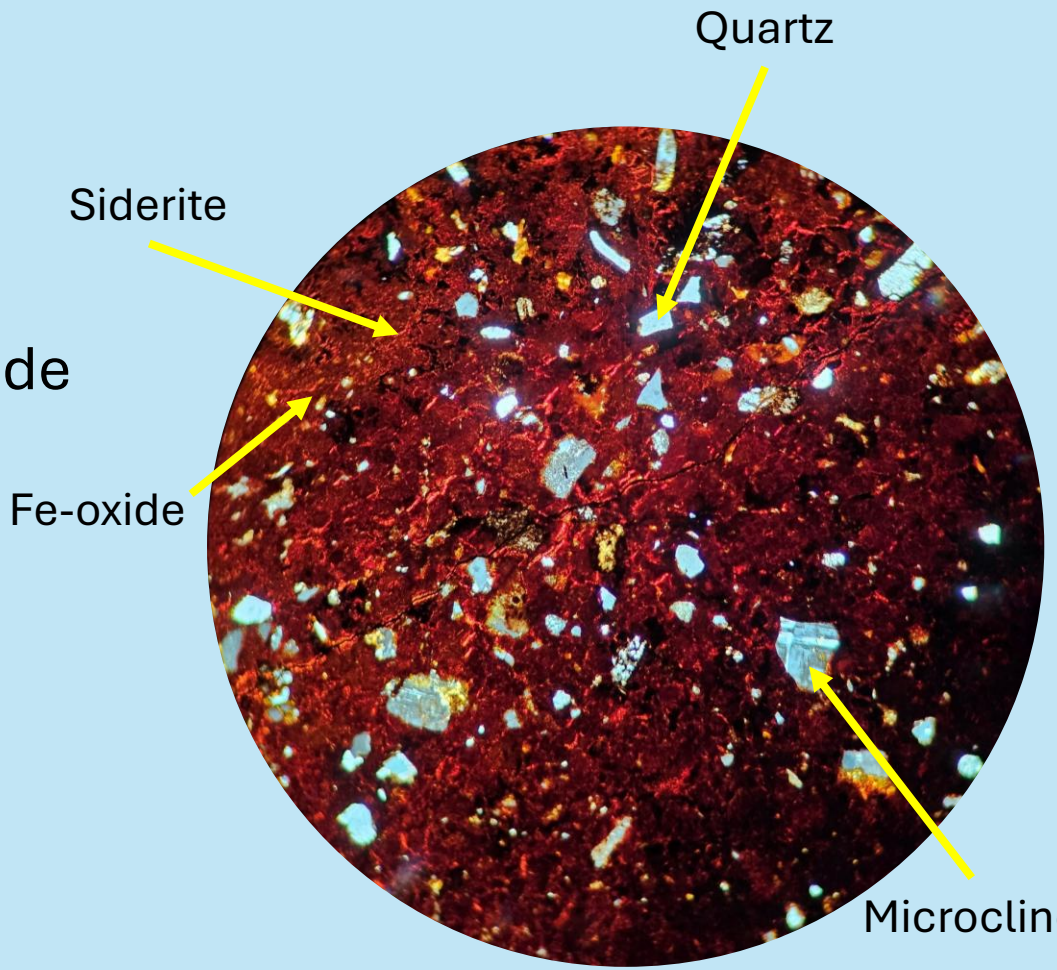
- Fracture filling (A)
- Sandstone cementation (B)
- Lens and nodular (C)
- Stratiform-laminated (D)

Fracture Filling Siderite

- Minerals present
  - Siderite cement
  - Microcline
  - Quartz
  - Alkali feldspar
  - Fe–oxide or hydroxide



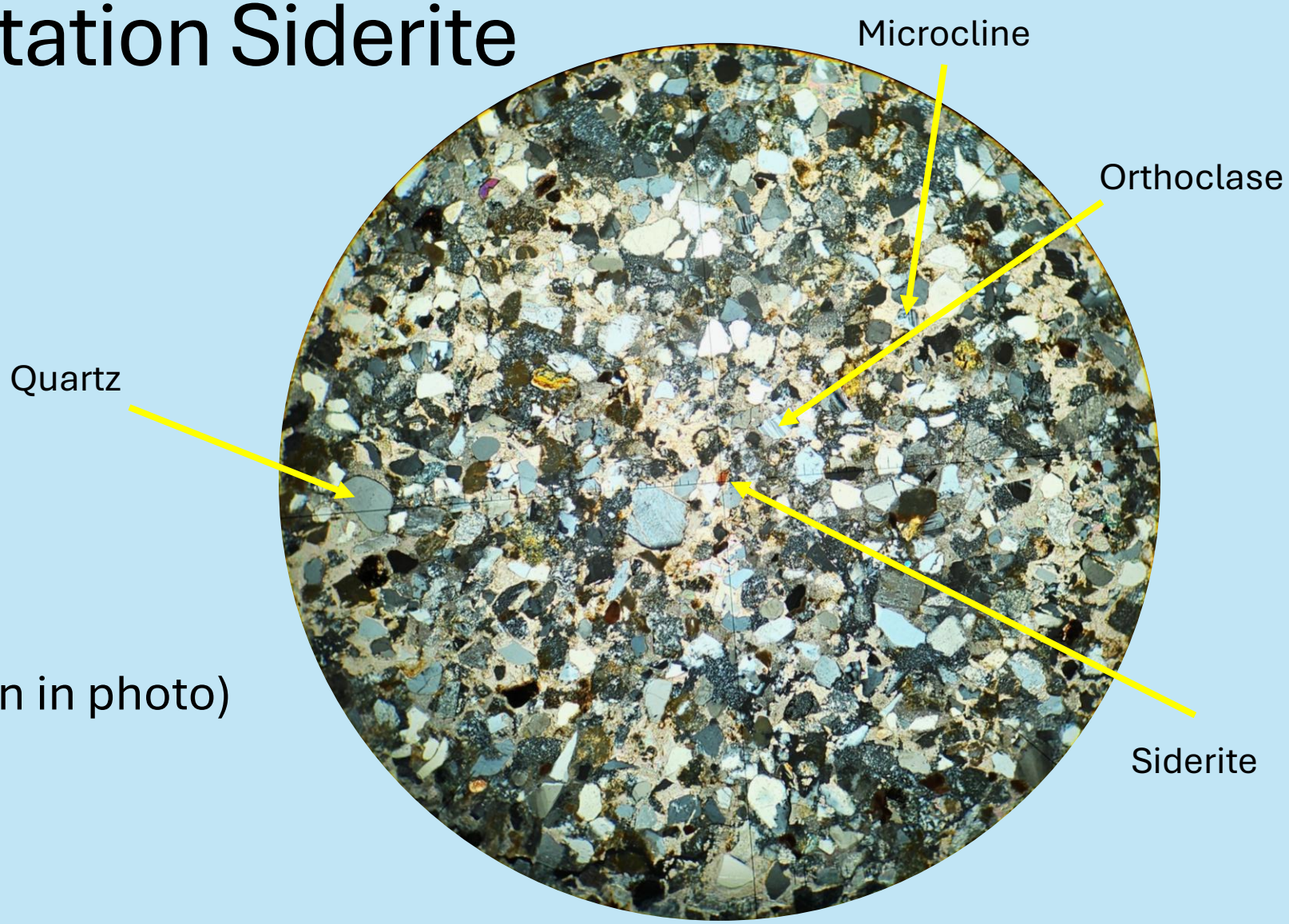
DS2-D PPL full thin section



Siderite matrix in XPL at 10x (DS2-D)

Sandstone Cementation Siderite

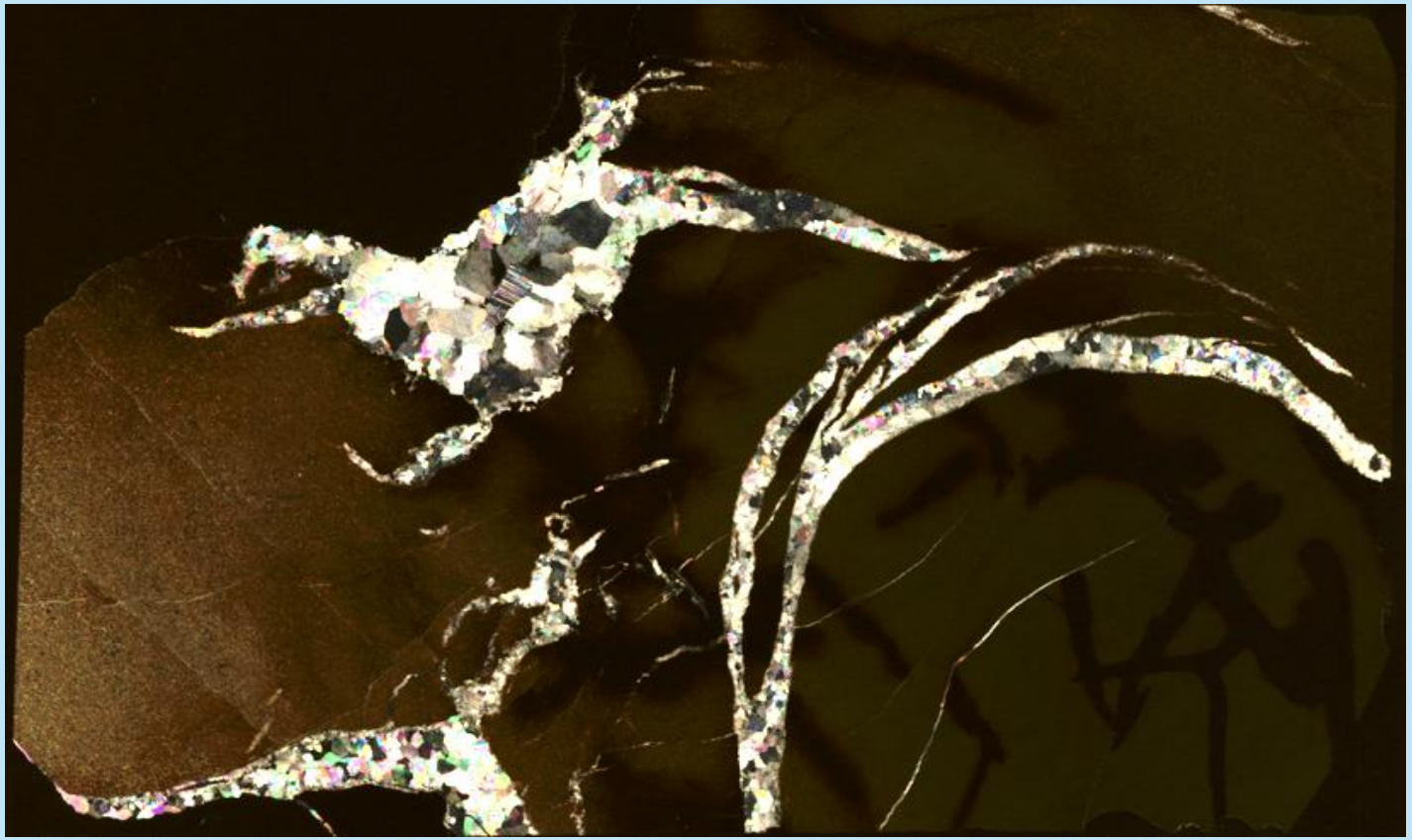
- Minerals Present
  - Quartz dominant
  - Microcline
  - Siderite
  - Orthoclase
  - Glauconite (not shown in photo)



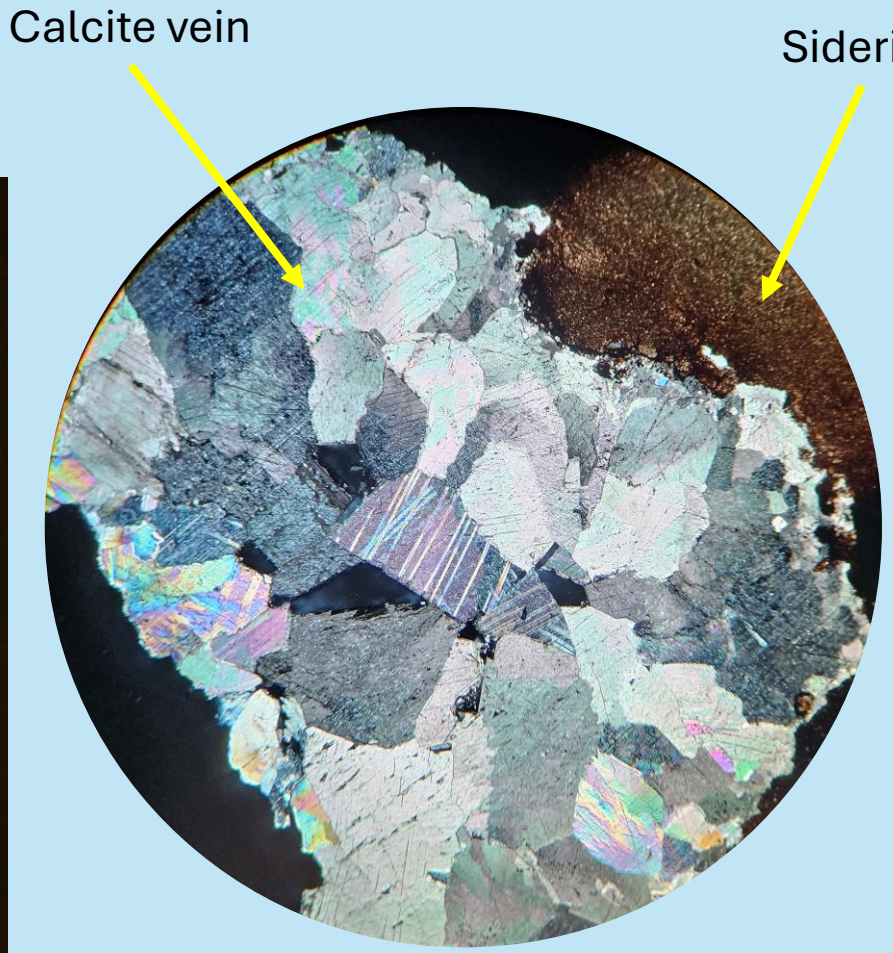
Siderite grain in XPL at 4x (ATS1-A)

Lens and Nodular Siderite

- Calcite vein in siderite cement



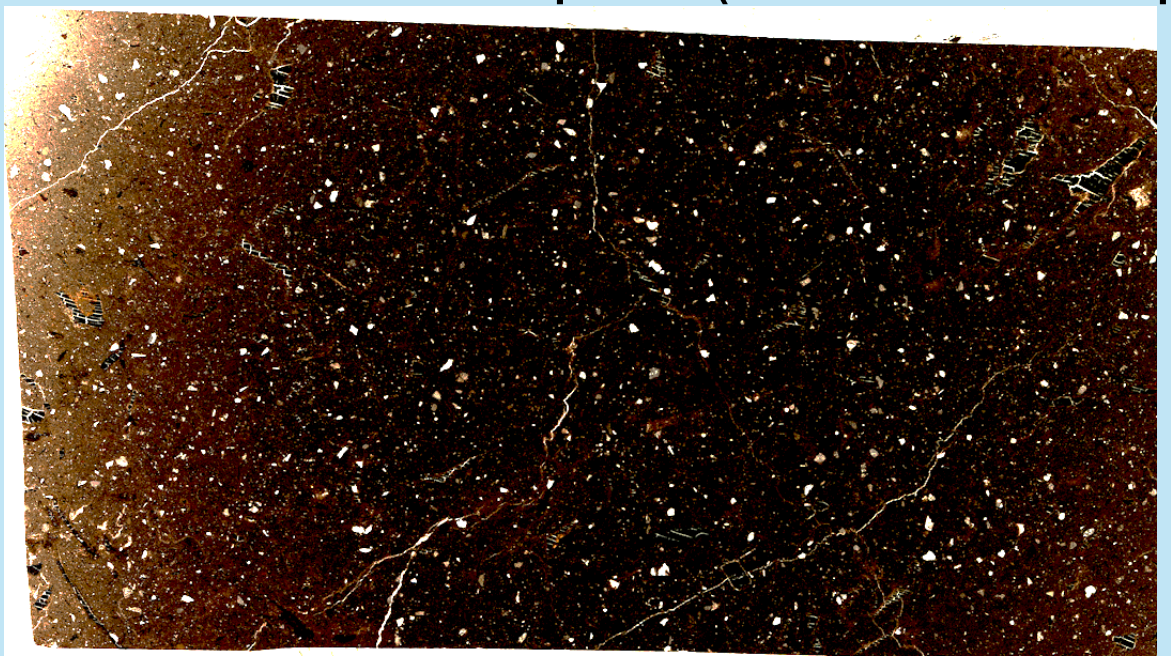
DS1-F XPL full thin section



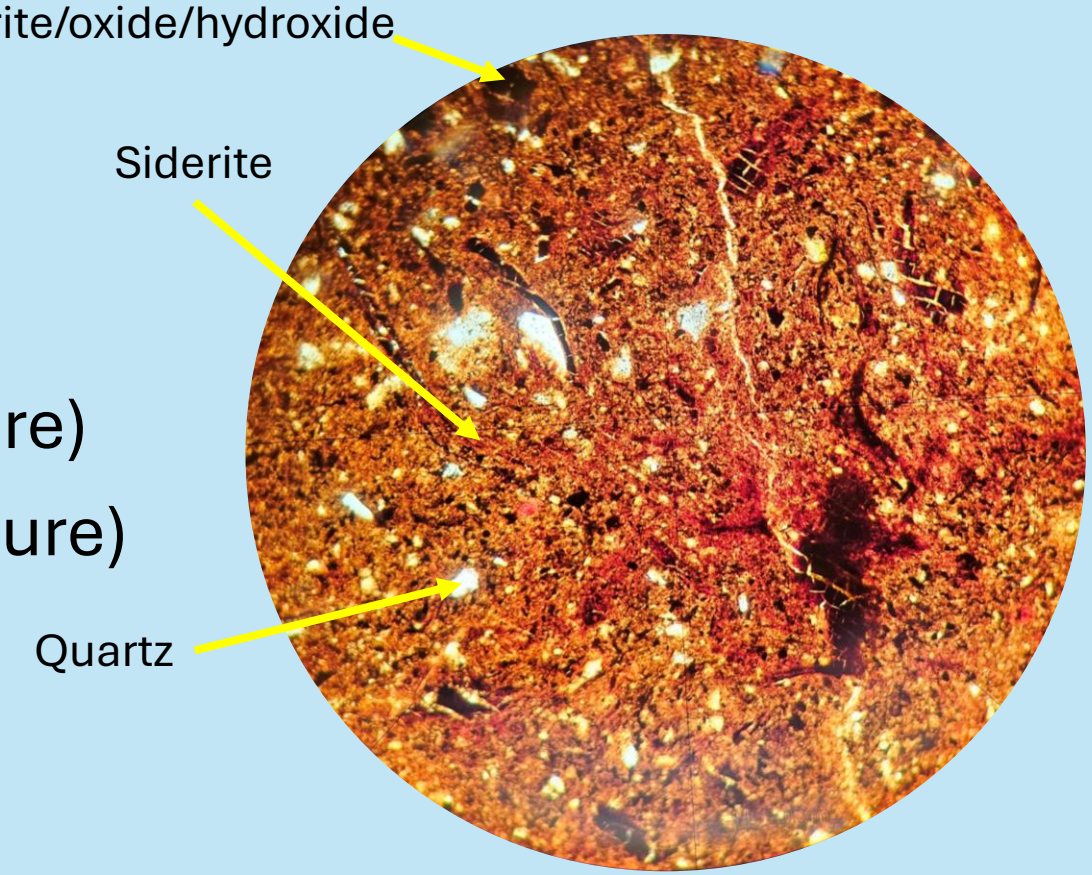
Calcite vein found in a siderite nodule in XPL at 10x (DS1-F)

Stratiform-laminated Siderite

- Ferrihydrite/oxide/hydroxide
- Siderite matrix
- Quartz
- Compressed Micas (not shown in picture)
- Microcline/feldspars (not shown in picture)

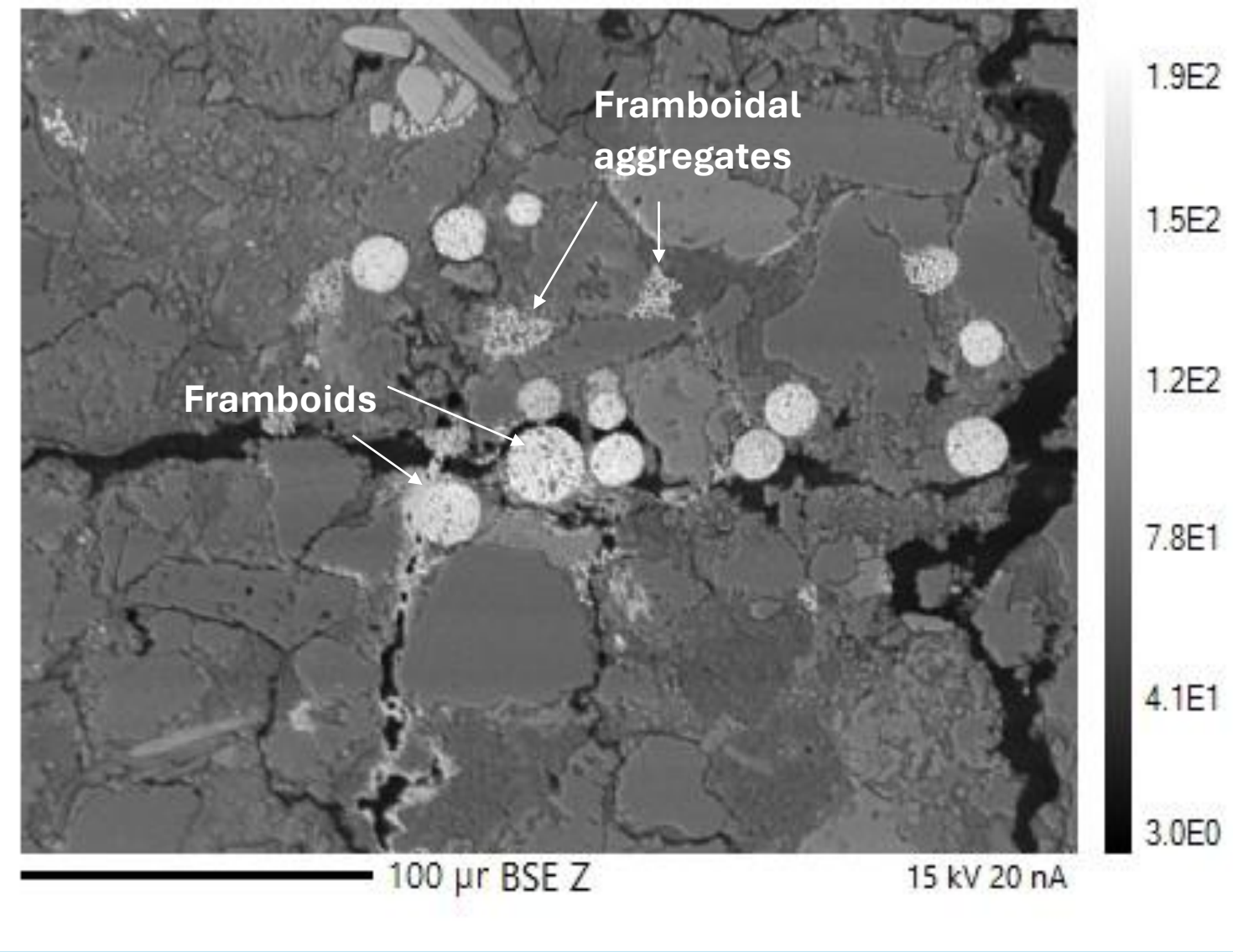


DS1-E PPL full thin section



Siderite matrix in PPL at 10x (DS1-E)

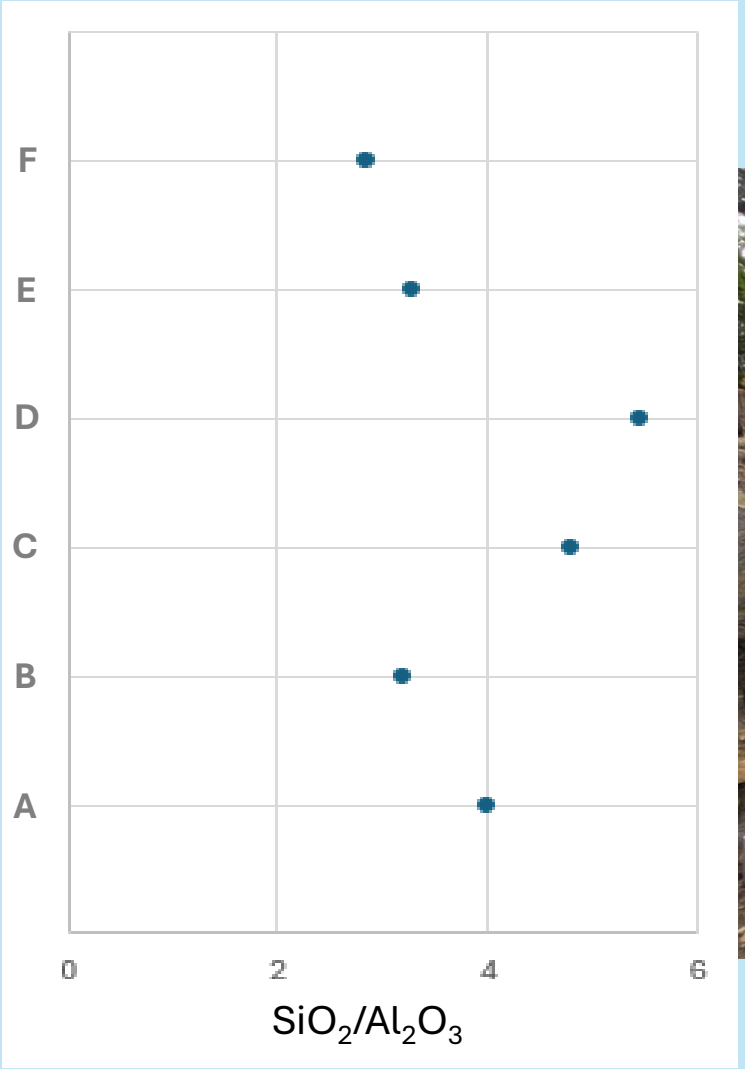
Framboidal Structures

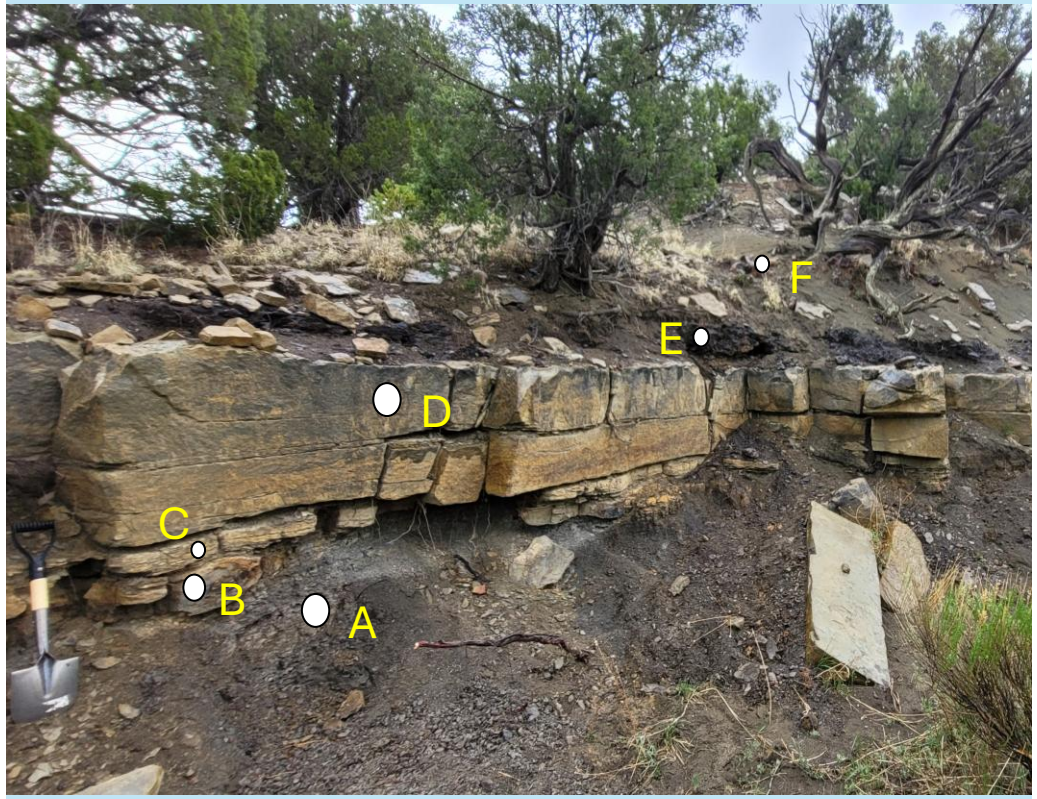


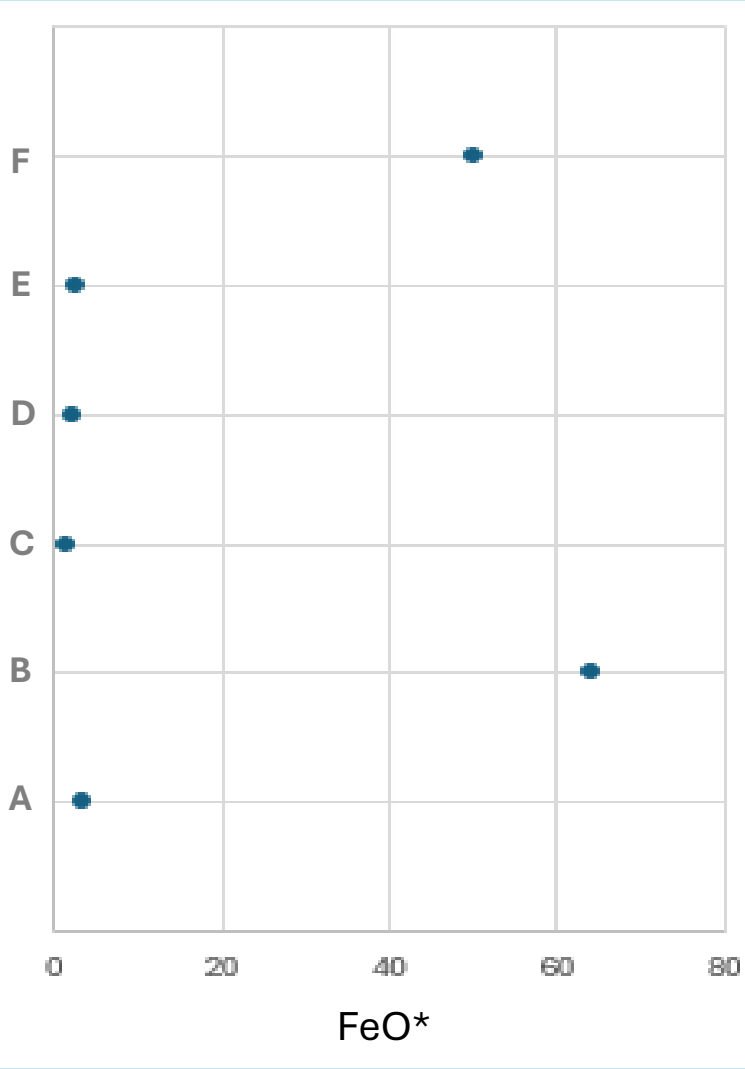
Acknowledgements

- Dr. Jennifer Thines
- Dr. Frank Ramos
- Dr. Brian Hampton
- A-Lan Reynolds
- Polito Walters
- Leo Kuyl
- WSU Geoanalytical Lab
- NMSU Microscope Imaging Core Suite
- New Mexico Bureau of Geology and Mineral Resources
- New Mexico Geological Society

Stratigraphic Correlation vs XRF/ICP-MS

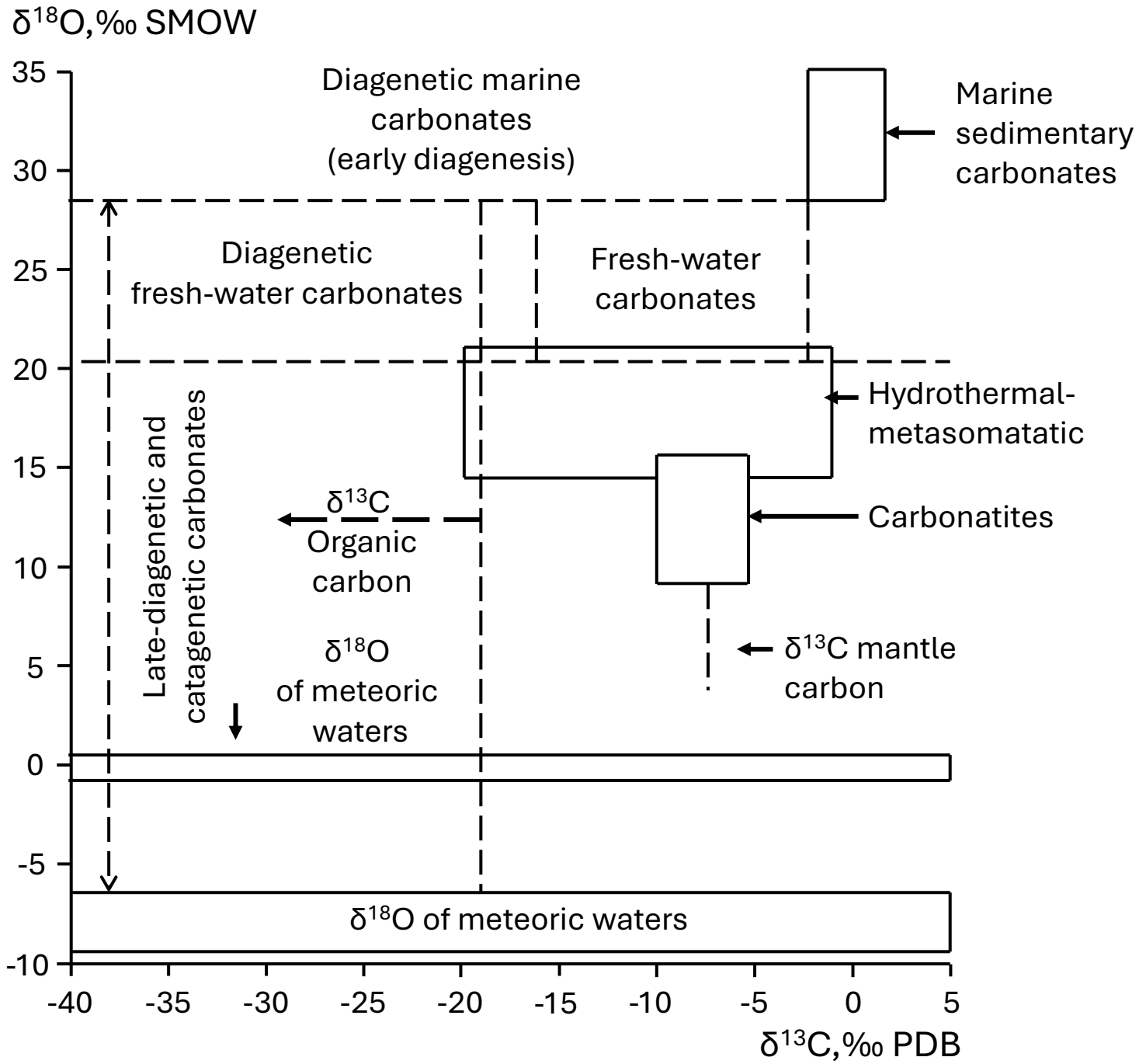






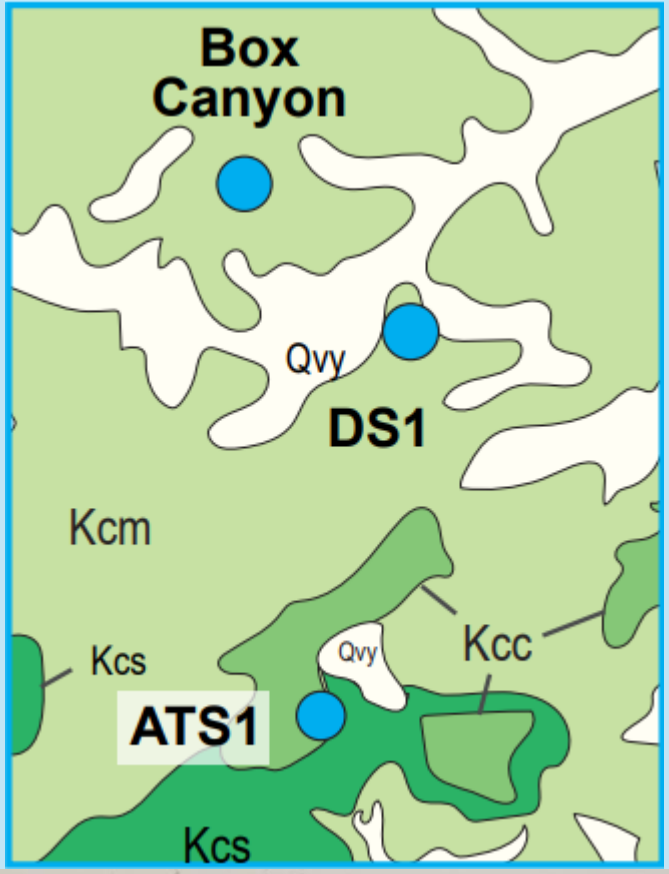
Plans for Future

- In-situ $\delta^{18}O$ and $\delta^{13}C$ analyses
- Continued SEM and EPMA work for higher resolution images
- Double checking outcrop scale textures



Crevasse Canyon Formation (Kcc)

Box Canyon

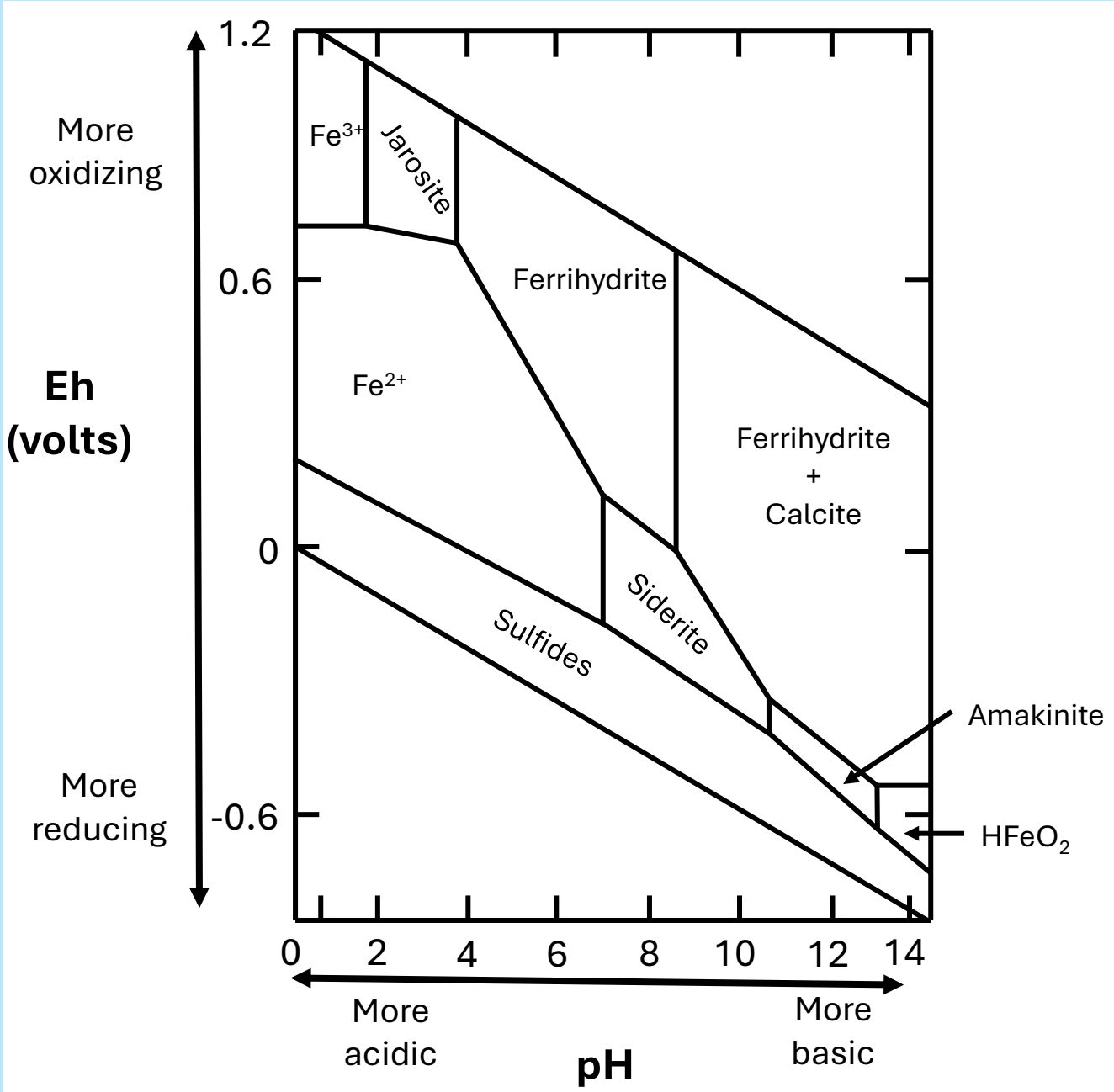


Methods

- 24 whole rock samples
  - Petrographic analysis
  - XRF major element concentrations
  - ICP-MS trace element concentrations
  - Carbonate mineral chemistry

Carbonate Precipitation

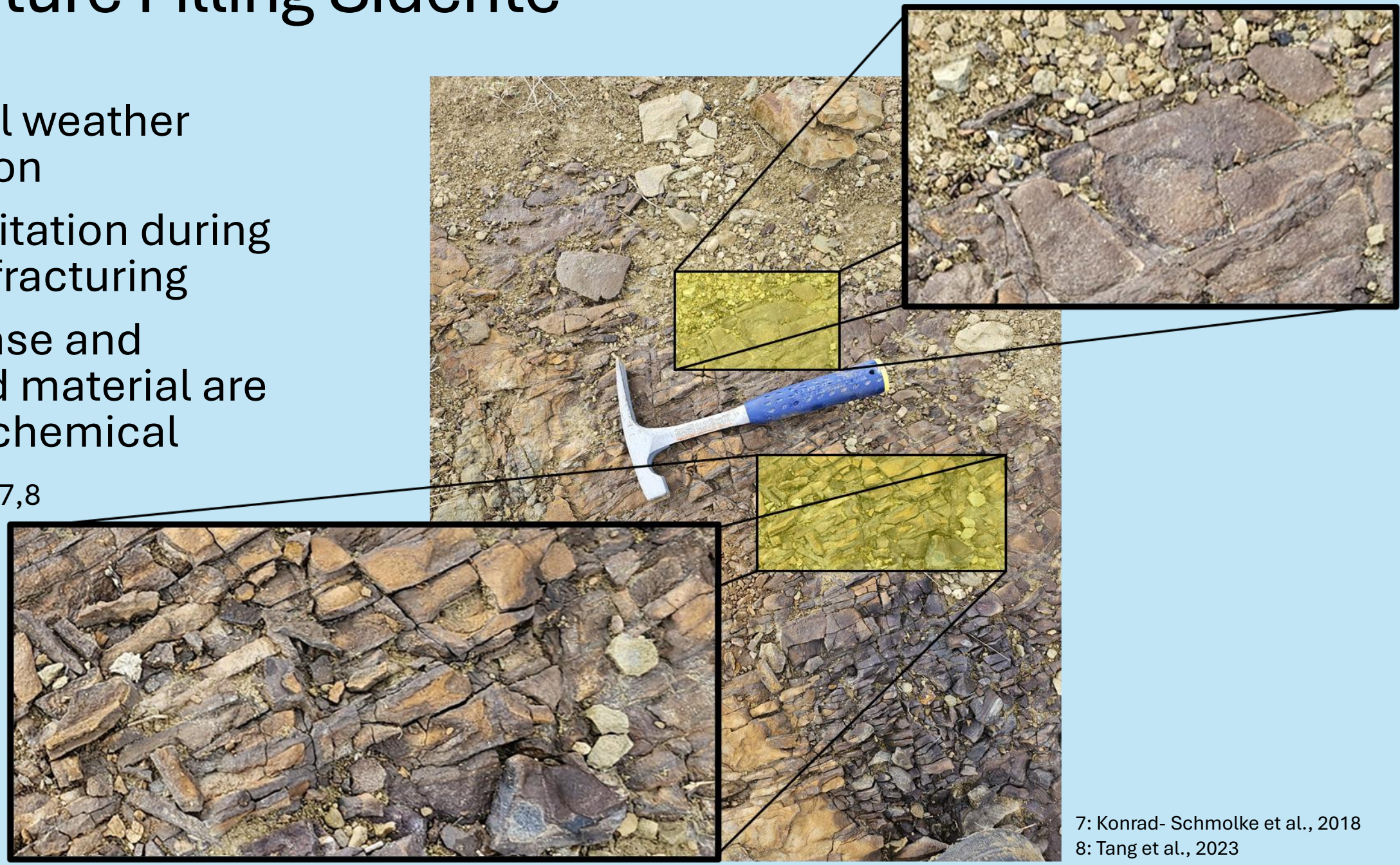
- Eh (oxidation-reduction potential) and pH dictate carbonation
- Calcite
  - Oxidized conditions
  - More alkaline water than siderite
- Siderite
  - Reduced conditions
  - Moderate alkaline water



(Macías and Camps-Arbestain, 2020)

(A) Fracture Filling Siderite

- Chemical weather dissolution
- Reprecipitation during regional fracturing
- Solid phase and dissolved material are equal in chemical potential[7,8]



7: Konrad- Schmolke et al., 2018
8: Tang et al., 2023

(B) Sandstone Cementation Siderite

- Pore-filling material between detrital particles
- Whole rock is typically brown-yellow in color
- Sandstone with calcite cement and discreet siderite grains

Lens and Nodular Siderite

- Hosted in mudstone/siltstone slope formers
- Purplish-gray to yellow in color in hand sample
- Microcrystalline (tens of microns) matrix in thin section

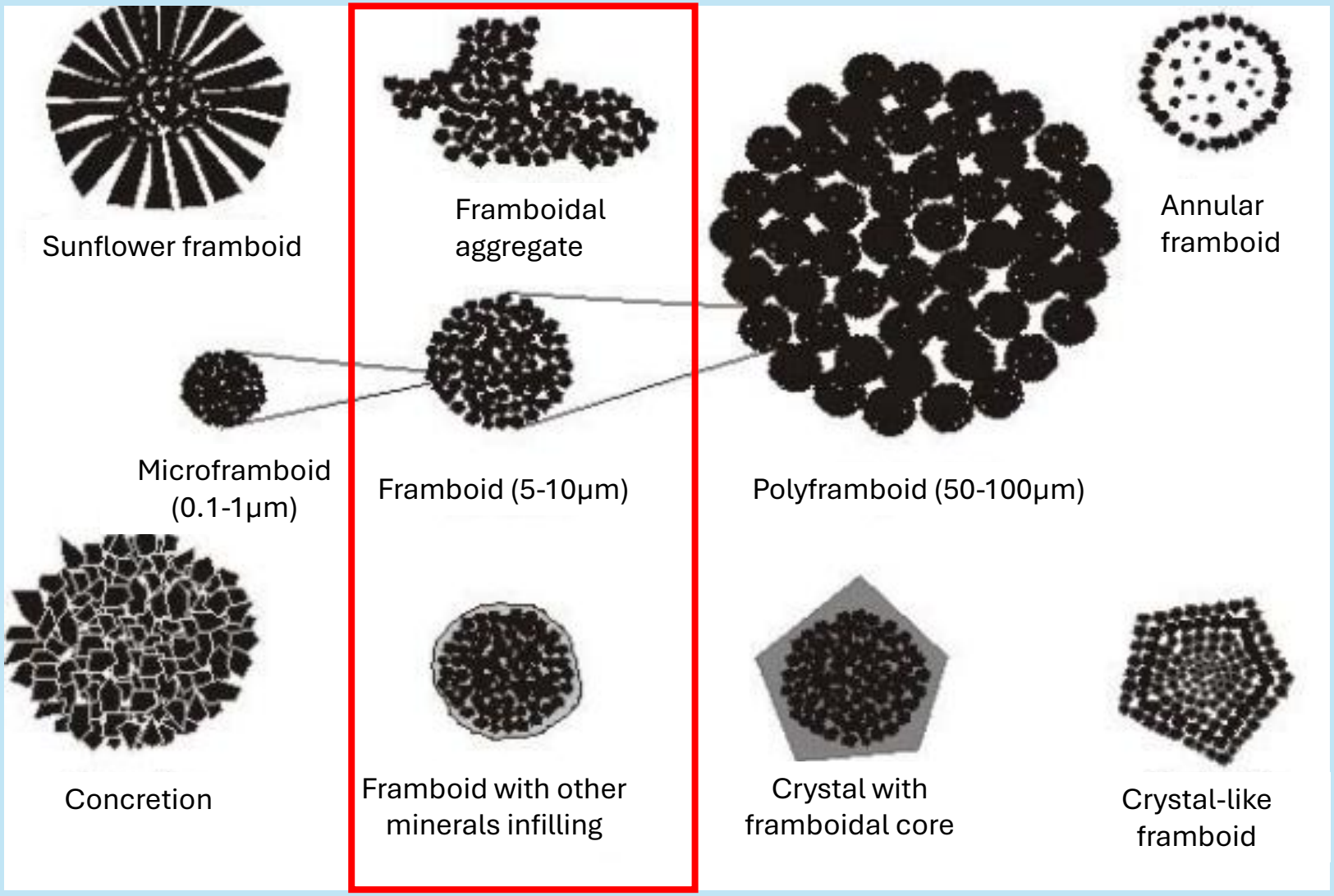
Stratiform-laminated Siderite

- Bluish gray to dark gray in hand sample
- Opaque in thin section with a siderite cement
- Fine grained (tens to hundreds of microns) siderite

(Sawlowicz, 2000)

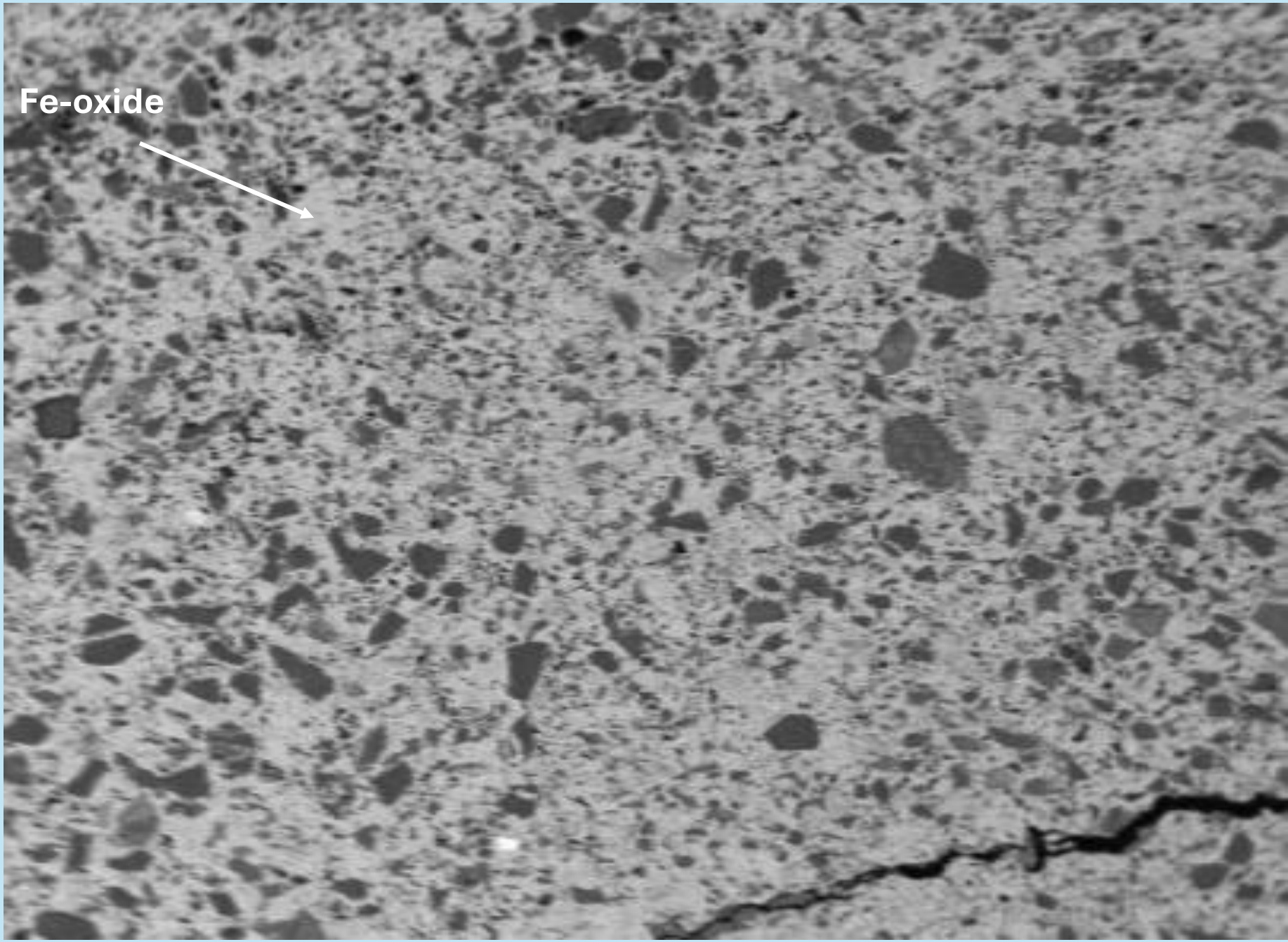
Framboidal Structures

- Three structures present
  - Framboidal aggregates
  - Framboids
  - Framboids infilled with potassium feldspar



Why Siderite over Calcite?

DS4-B



Potential Sources of Fe

- Anaerobic redox cycling from freshwater microorganisms[9]
- Micas
- Fe-oxides
- Glauconite
- Potassium Feldspar (up to 1-1.5 wt% FeO total)

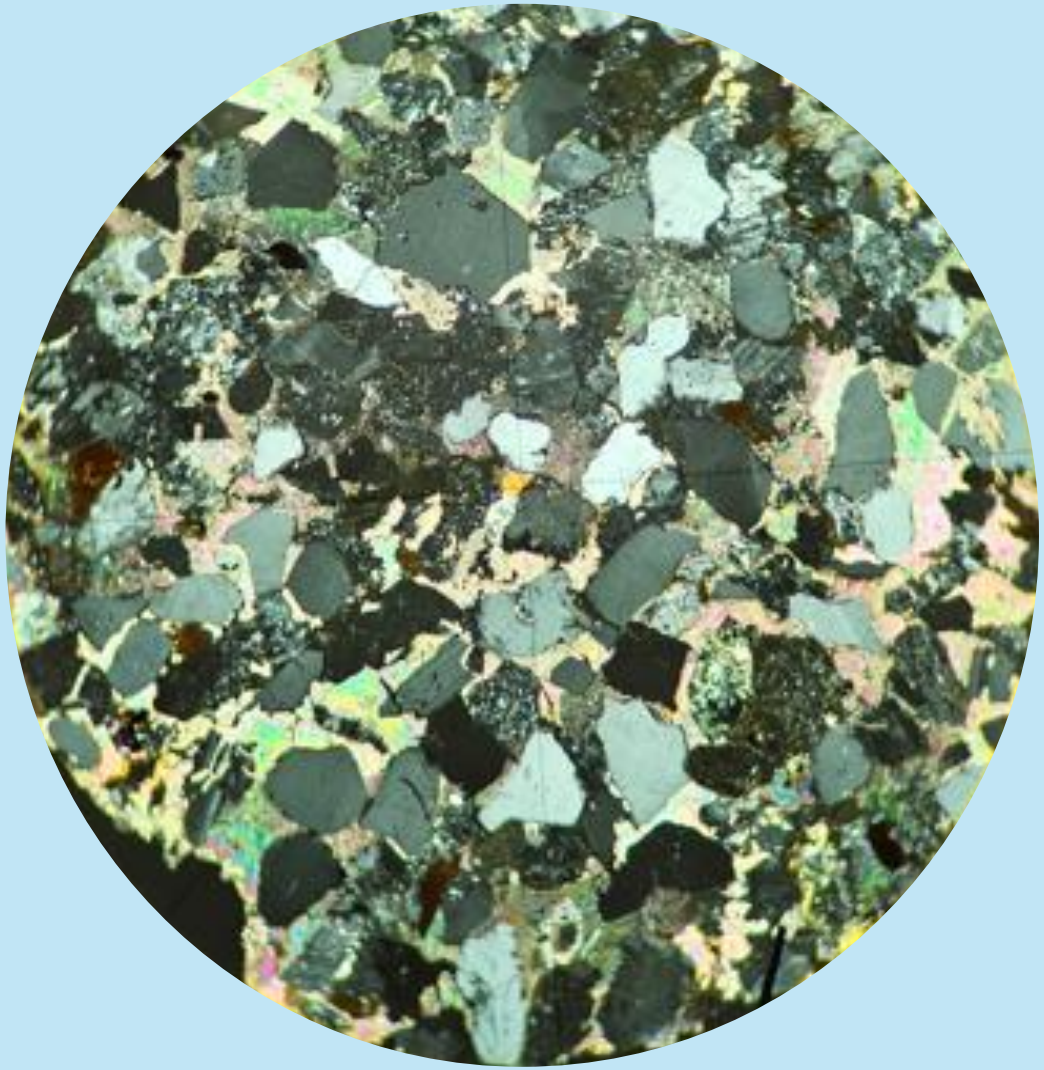
9: Weber et al. 2006

Goals of the Study

- Detailed petrographic analysis of the fine-grained sedimentary rocks of the Crevasse Canyon Formation
- Determine if the textural differences in hand sample and microscopic scales coincide with composition
- Identify the sedimentary and diagenetic environments causing siderite and calcite precipitation
- Co-precipitation vs multi-stage precipitation event of siderite and calcite

Petrographic Analysis

- Origin
  - Sedimentary
- Mineral content
  - Fe-oxides and ferrihydrite
  - Quartz
  - Micas
  - Alkali feldspars
  - Carbonates



Textural Difference and Composition

- Fine-grained vs coarse grained
  - Hand sample
  - Microscopic scale
- Structural differences
  - Cement
  - Matrix
  - Grain size and shape
- Composition

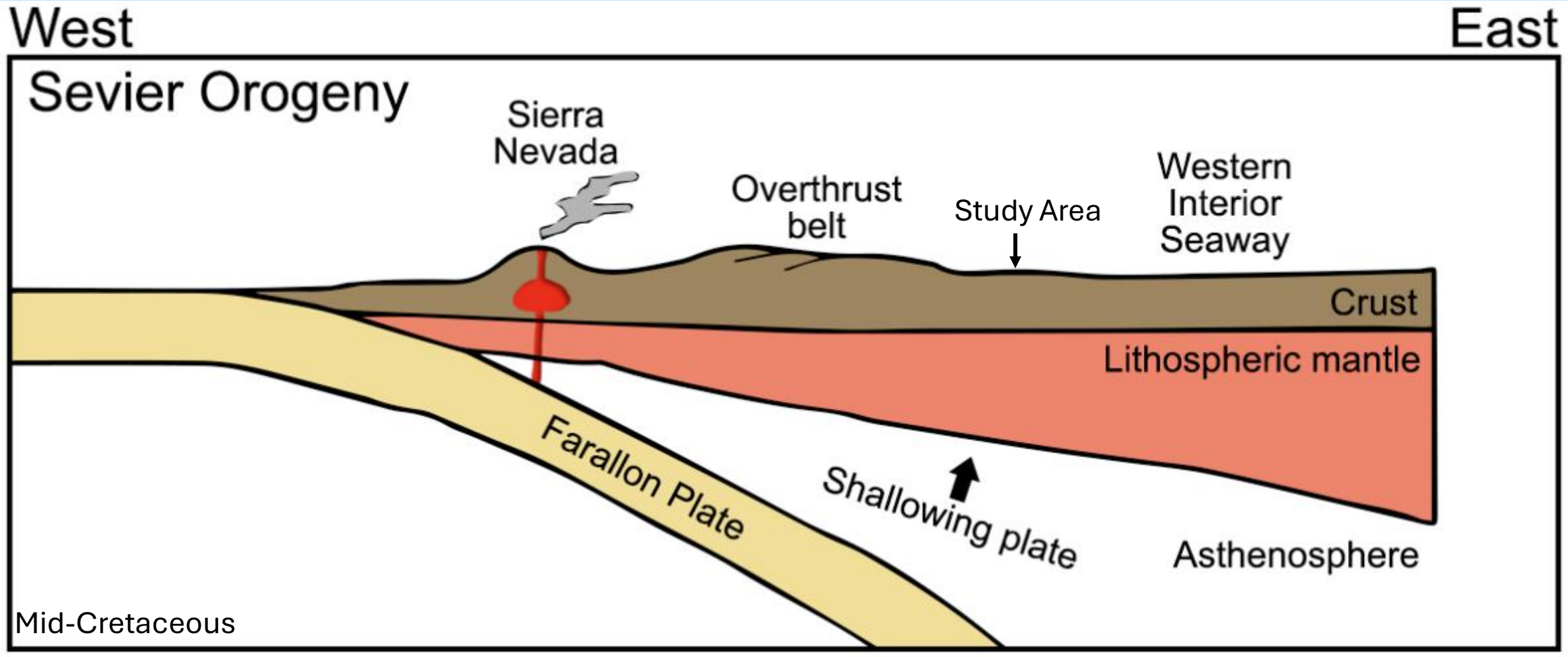
Sedimentary and Diagenetic Environments

- Origin of sediments
  - Source of Fe
- Water source
  - Fluvial
  - Marine
  - Deltaic

Precipitation of Siderite and Calcite

- Co-precipitation
- Multi-stage precipitation
- Both
- Eodiagenetic
- Mesodiagenetic

Farallon Plate & Sevier Orogeny



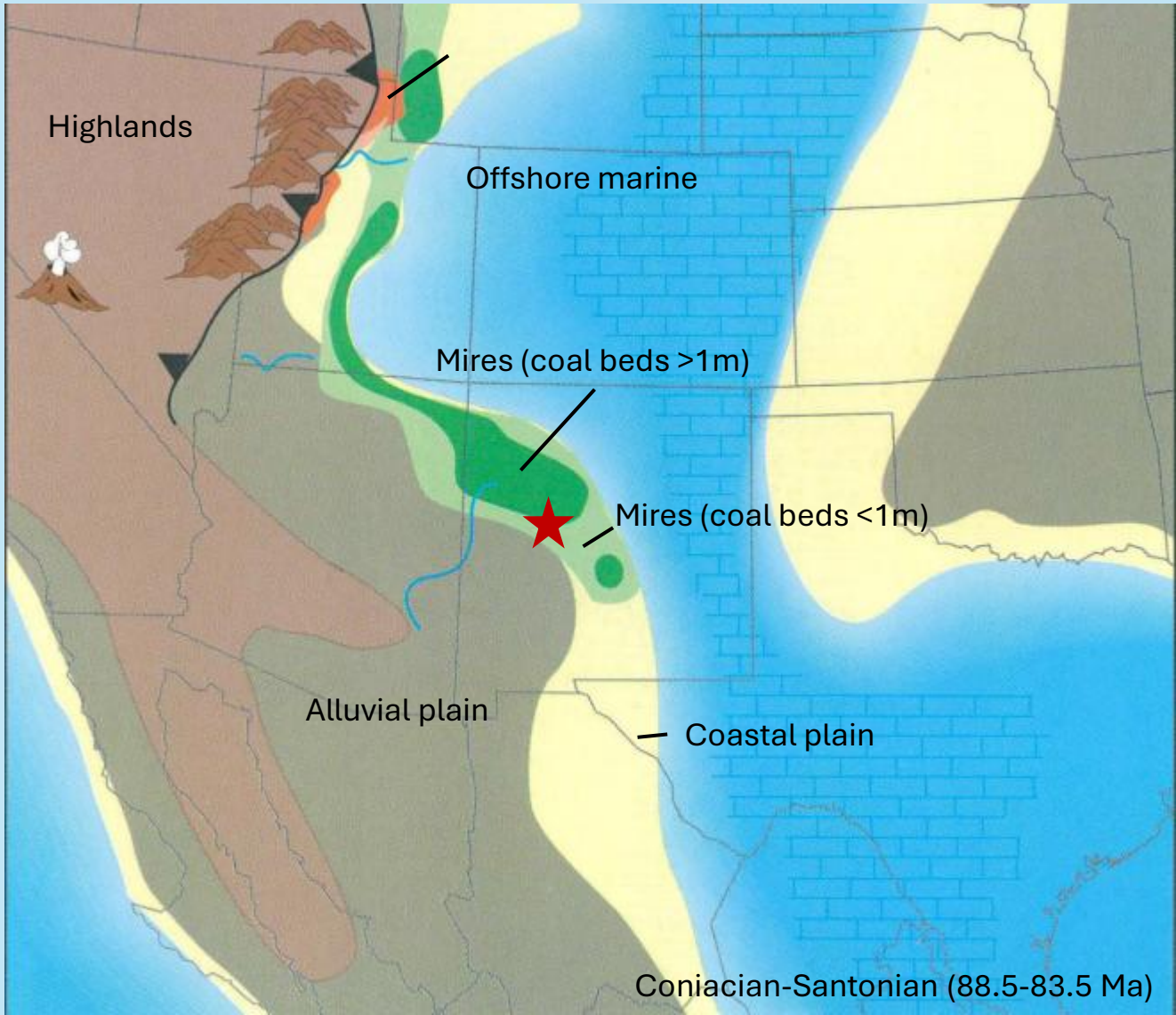
(Swaby et al. 2016)

3: Lowery et al., 2018
4: Van Cappelle et al., 2018

Western Interior Seaway

(Roberts and Kirschbaum, 1995)

- Subsidence from Farallon Plate subduction
  - Cooling of asthenosphere[3,4]
- Sevier Orogeny
  - Further subsidence
- Flooding from sea level rise
- Cyclical transgressions and regressions

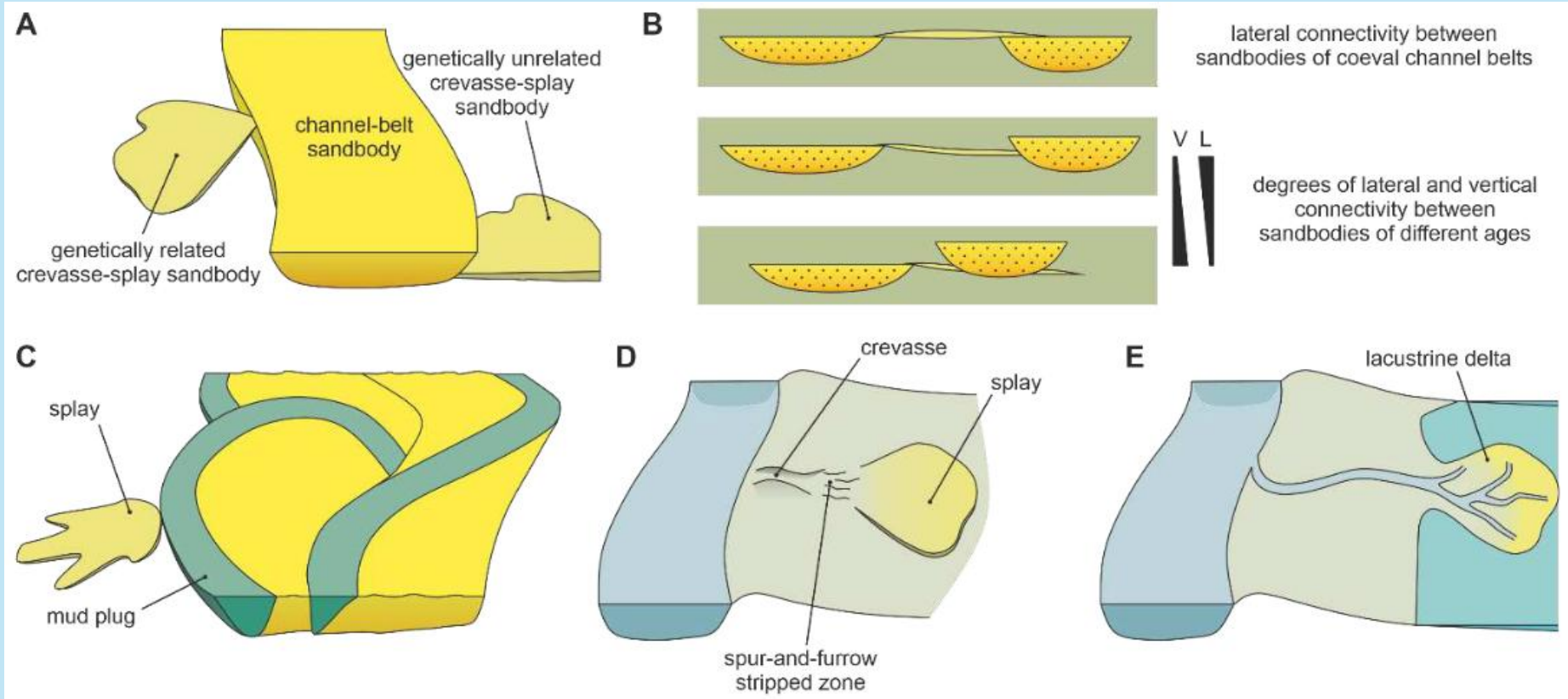


★ Field of study

What are splays?

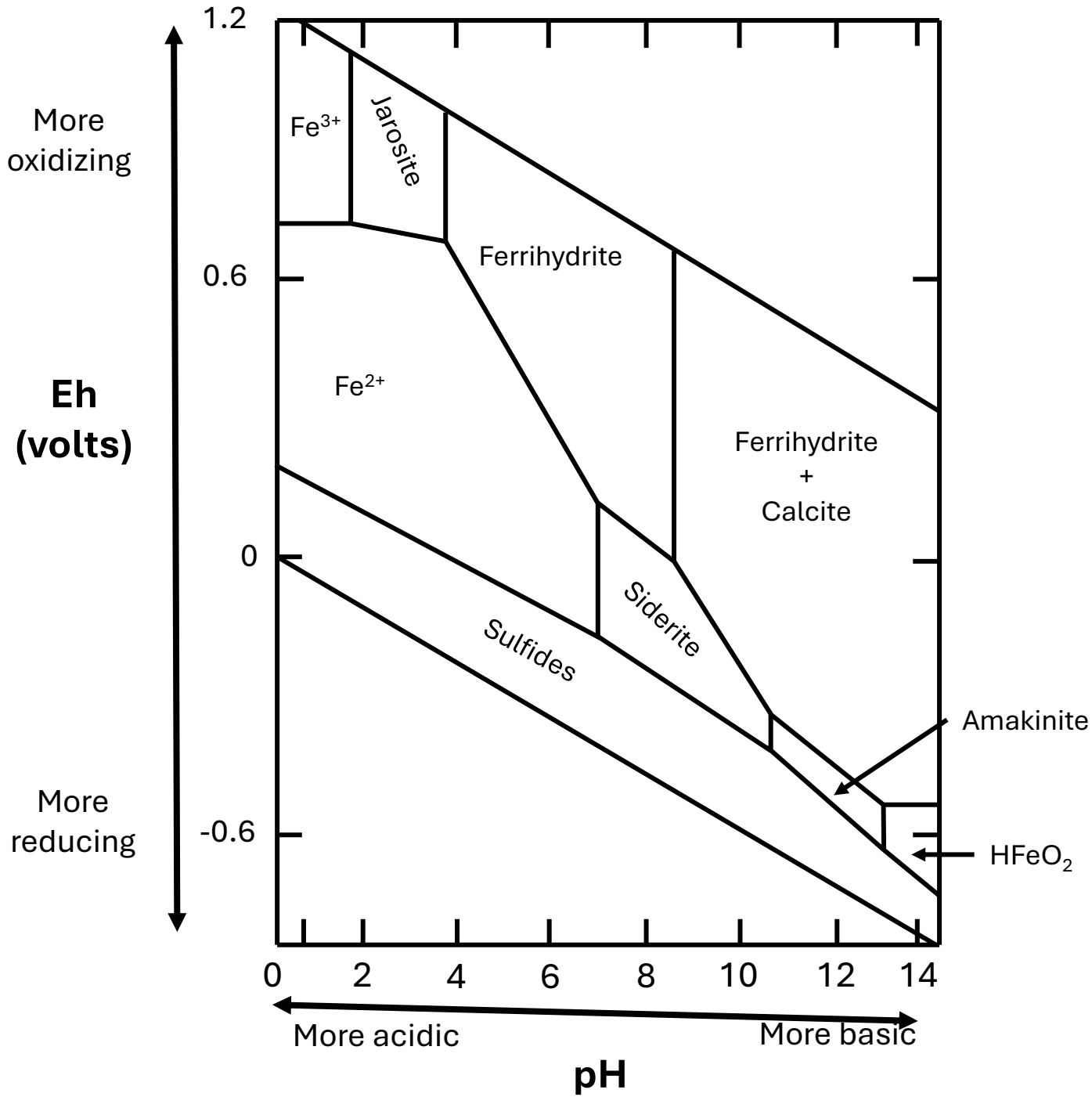
- Lithified areas of sedimentary sinks that have high concentrations of carbon[6]
- Typically associated with hydrocarbon reservoirs

(Colombera and Mountney, 2021)



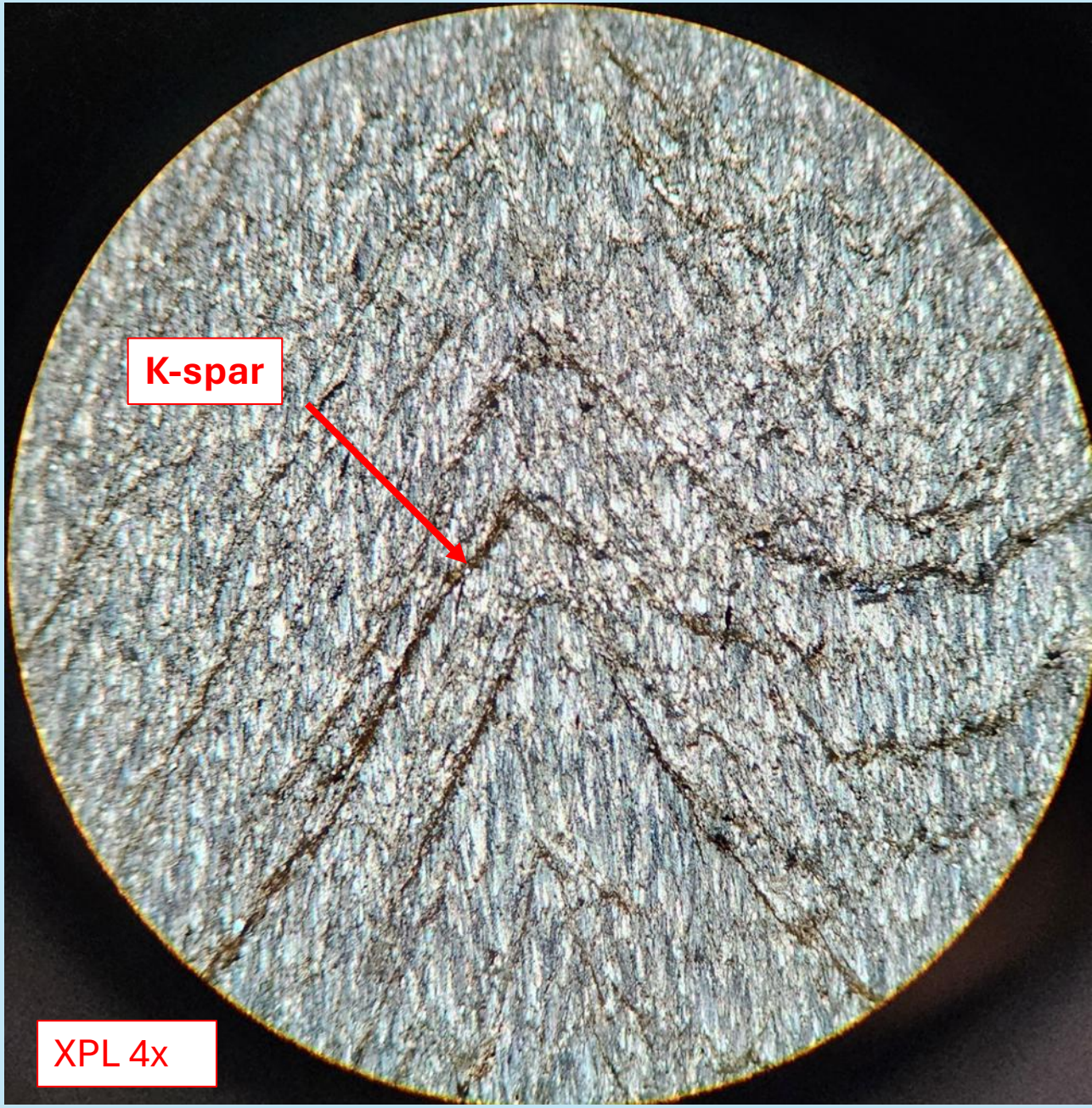
6: Colombera and Mountney, 2021

Why Siderite over Calcite?



Cone-in-cone Structures

- Fibrous calcite in thin section
- Texture used to determine diagenetic environment (Ábalos and Elorza, 2011)
- Altered K-spar in thin section follows cone-in-cone structure



Cone-in-cone Structures

- Cone-shaped growth pattern of calcite
- Origin is debated (Franks, 1969)
  - Soft sediment deformation
  - Pressure caused by recrystallization during early diagenesis
- In contact with shales and sandstones

Future work / implications

- Stable isotope geochemistry
  - $\delta\,^{18}O$
  - $\delta\,^{13}C$
- Oxidized or reduced environment
- Degassing of coal in area

(Ochoa et al., 2007)

Siderite in Mesodiagenesis

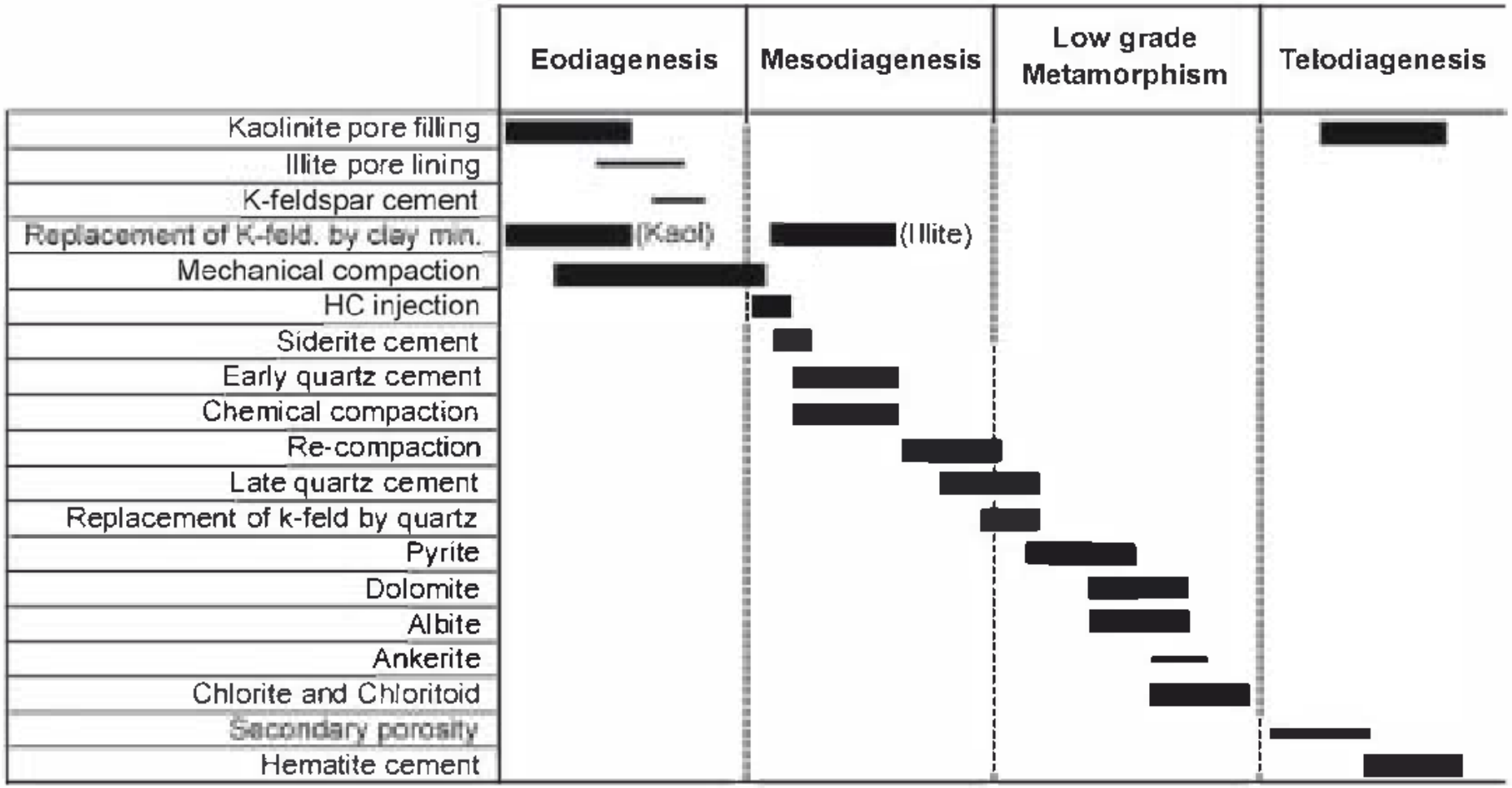


Fig. 8. Chronology of the main post-depositional processes and products ascribed to eodiagenesis, mesodiagenesis, telodiagenesis and to the metamorphic event (shaded zone).

(Permanyer et al., 2015)

Siderite in Eodiagenesis

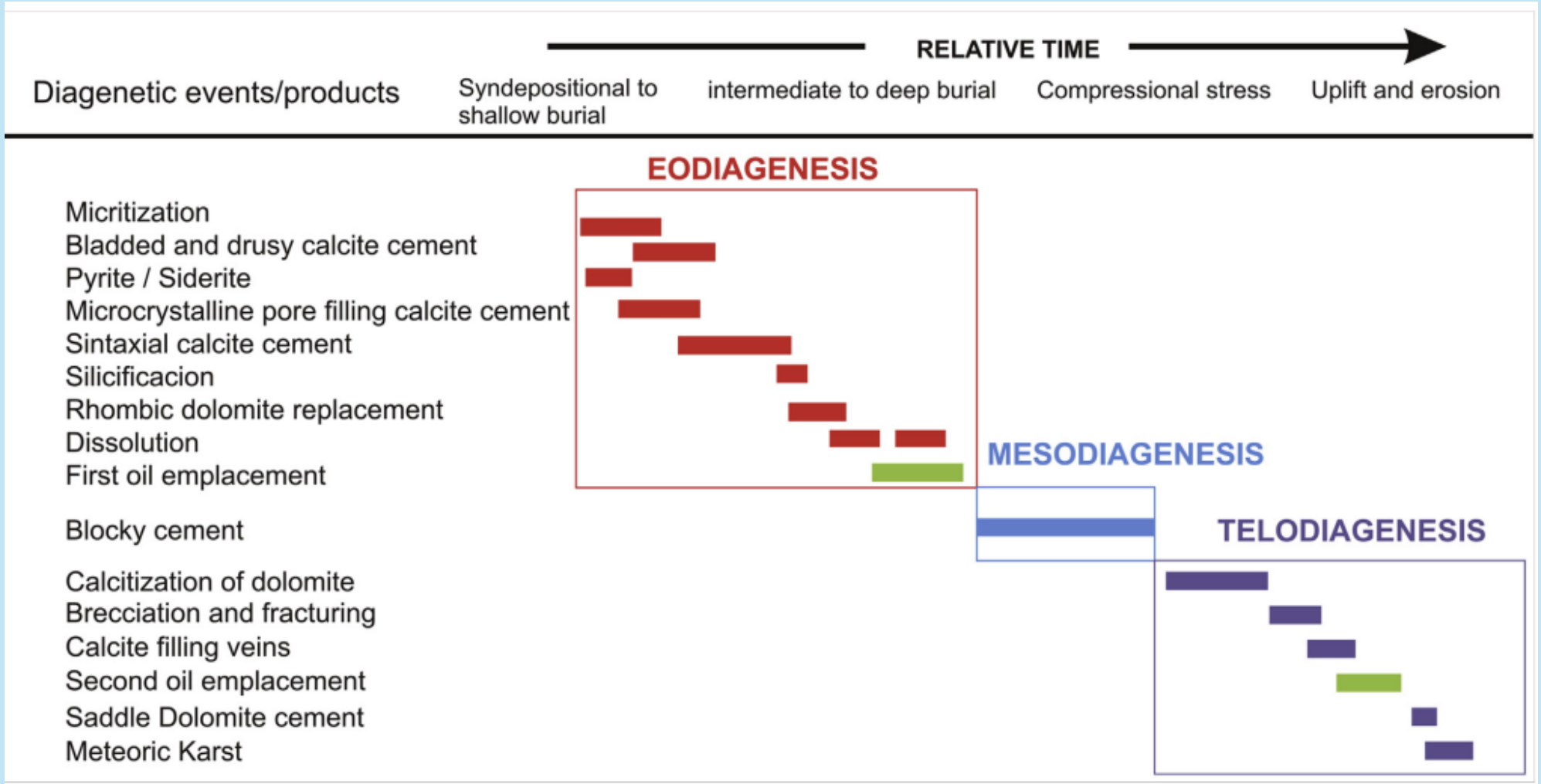
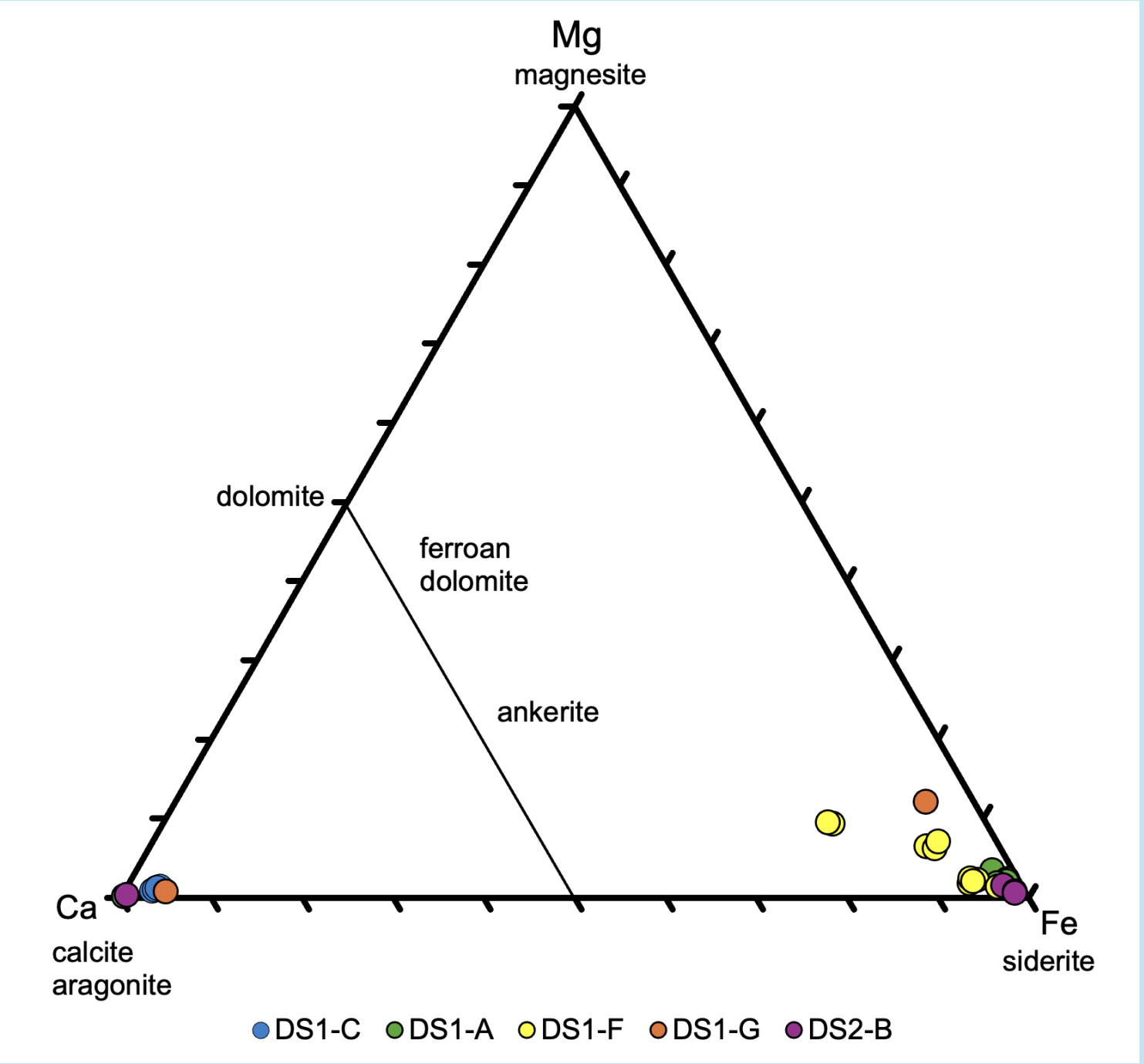


Fig. 15. Paragenetic sequence showing relative timing of the diagenetic alterations observed in the sandstone and carbonate samples.


Mg
magnesite
dolomite
ferroan
dolomite
ankerite
Ca
calcite
aragonite
Fe
siderite
DS1-C
DS1-A
DS1-F
DS1-G
DS2-B