



Sedimentology and Petrology of a Carbon Capture and Sequestration Reservoir and Seal

By:

Jared T. Freiburg

David Morse

Hannes E. Leetaru



ILLINOIS STATE
GEOLOGICAL SURVEY
PRAIRIE RESEARCH INSTITUTE



TM

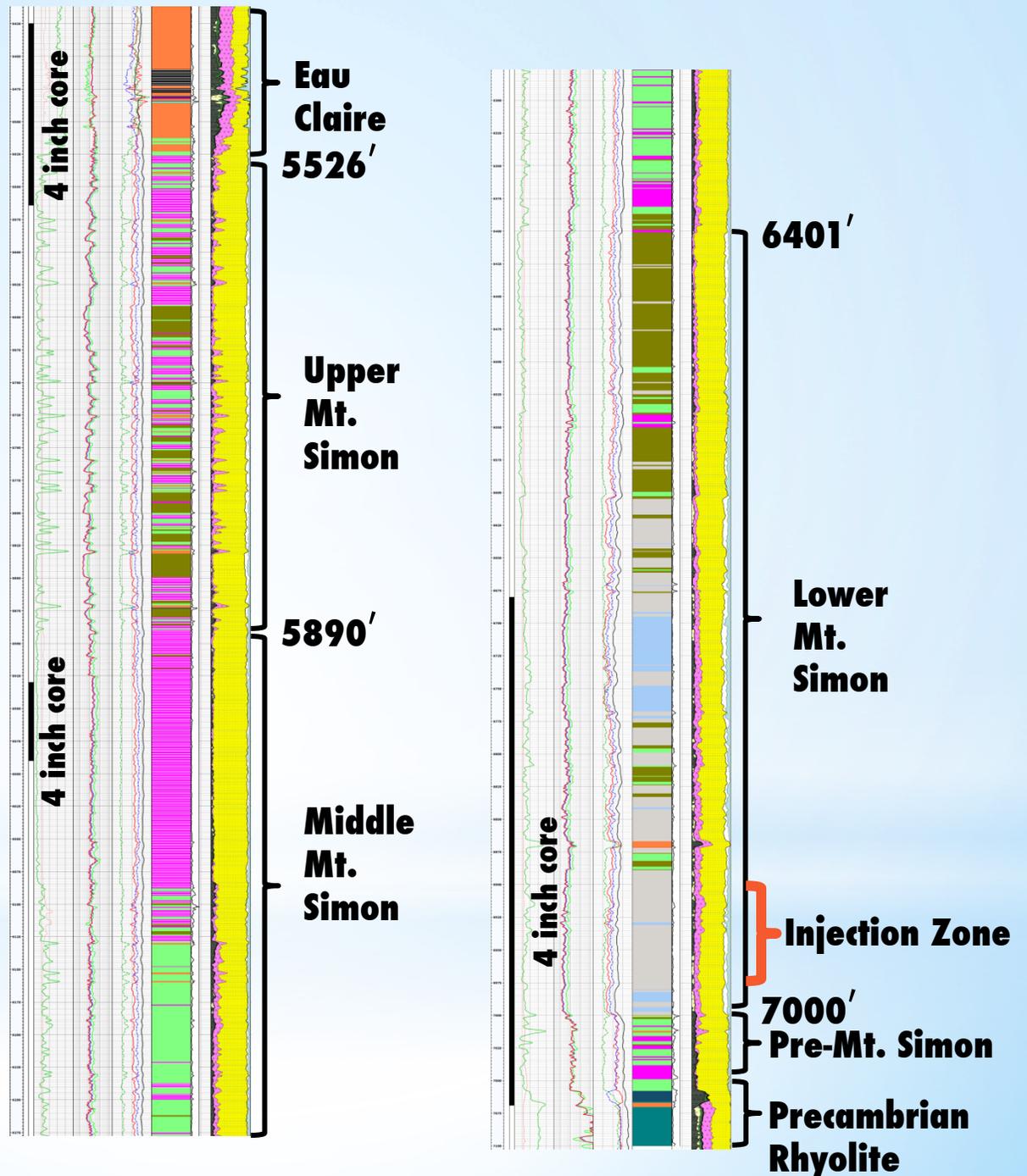
Introduction

In the Illinois Basin the Mt. Simon Sandstone is an excellent reservoir for CCS with the overlying Eau Claire formation cap rock.

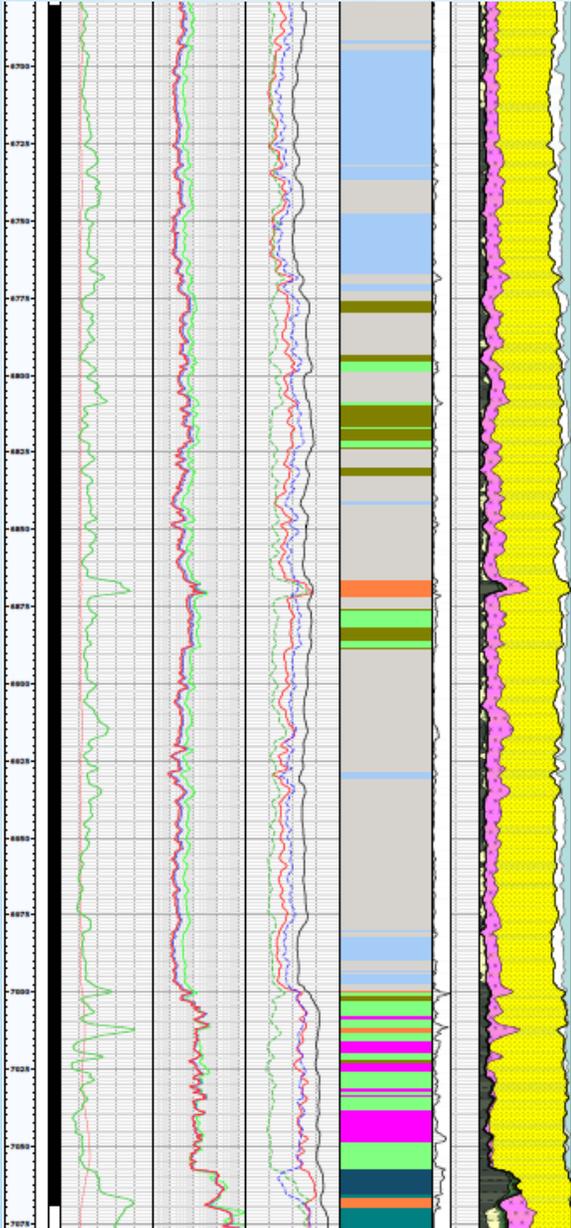
How do depositional facies and diagenesis control reservoir and seal properties?

Verification Well #1 Heterogeneous Rock Analysis (HRA)

- HRA evaluates log responses to define heterogeneities in the rock
- Mt. Simon Sandstone is approximately 1,600 feet thick.
- Divided into three major sections with abundant facies
- Overlain by Eau Claire Formation



Lower Mt. Simon



- Injection Zone
- Coarse to medium-grained sandstone and conglomerates
- Excellent Reservoir!

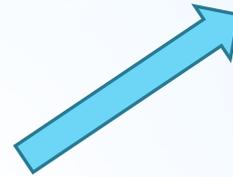
4" Core

Lower Mt. Simon Depositional Environment

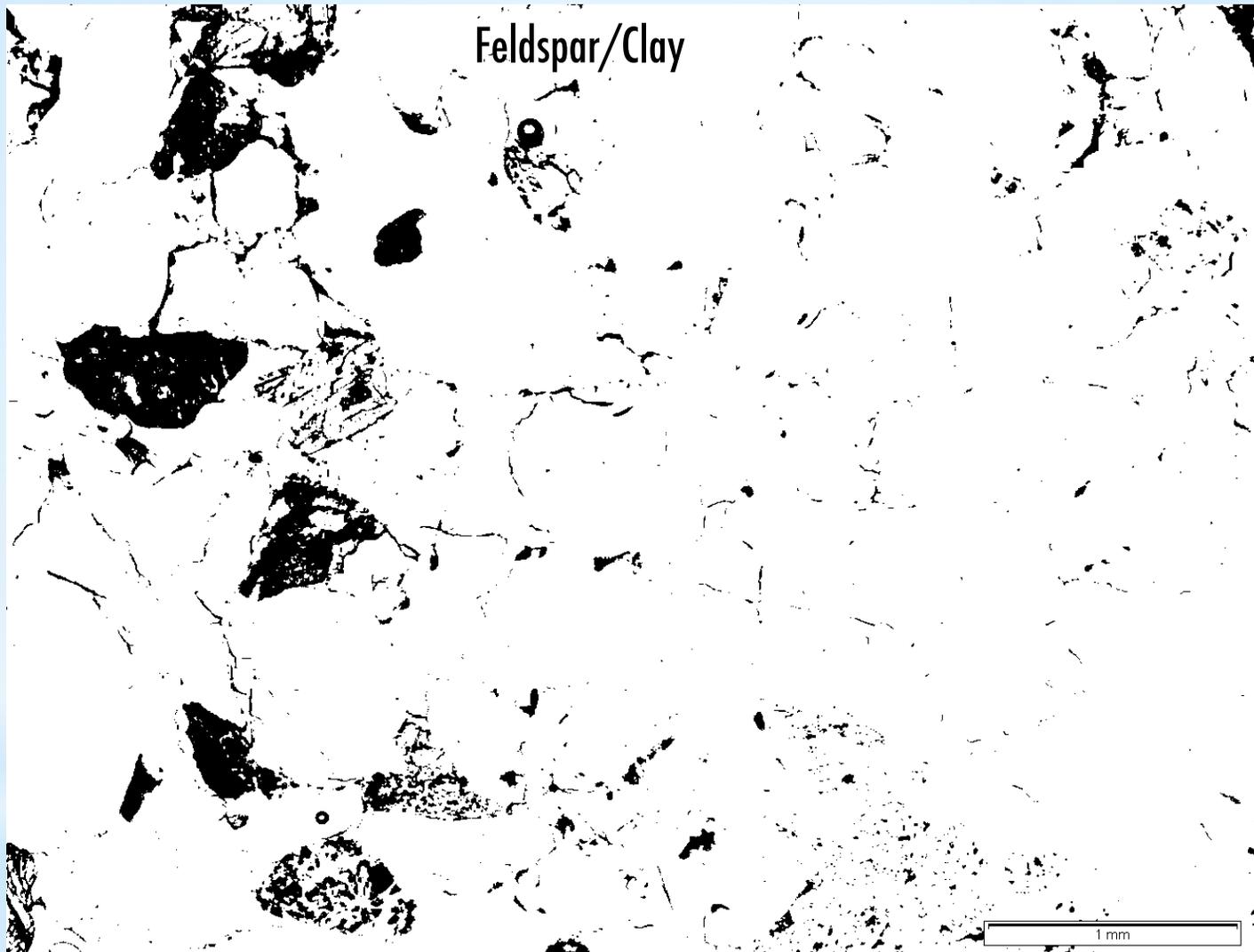
- Fluvial-Braided River
- Fluvial-Eolian-Playa/Interdune

Characterized By:

- Coarse grained, cross-bedded sandstone to pebble conglomerates (Fluvial-Braided Stream)
- Medium to fine grained, cross-bedded, planar and ripple laminated, and mottled sandstones the occasional coarse to pebble lags (Fluvial-Eolian-Playa/Interdune)



Lower Mt. Simon Petrography

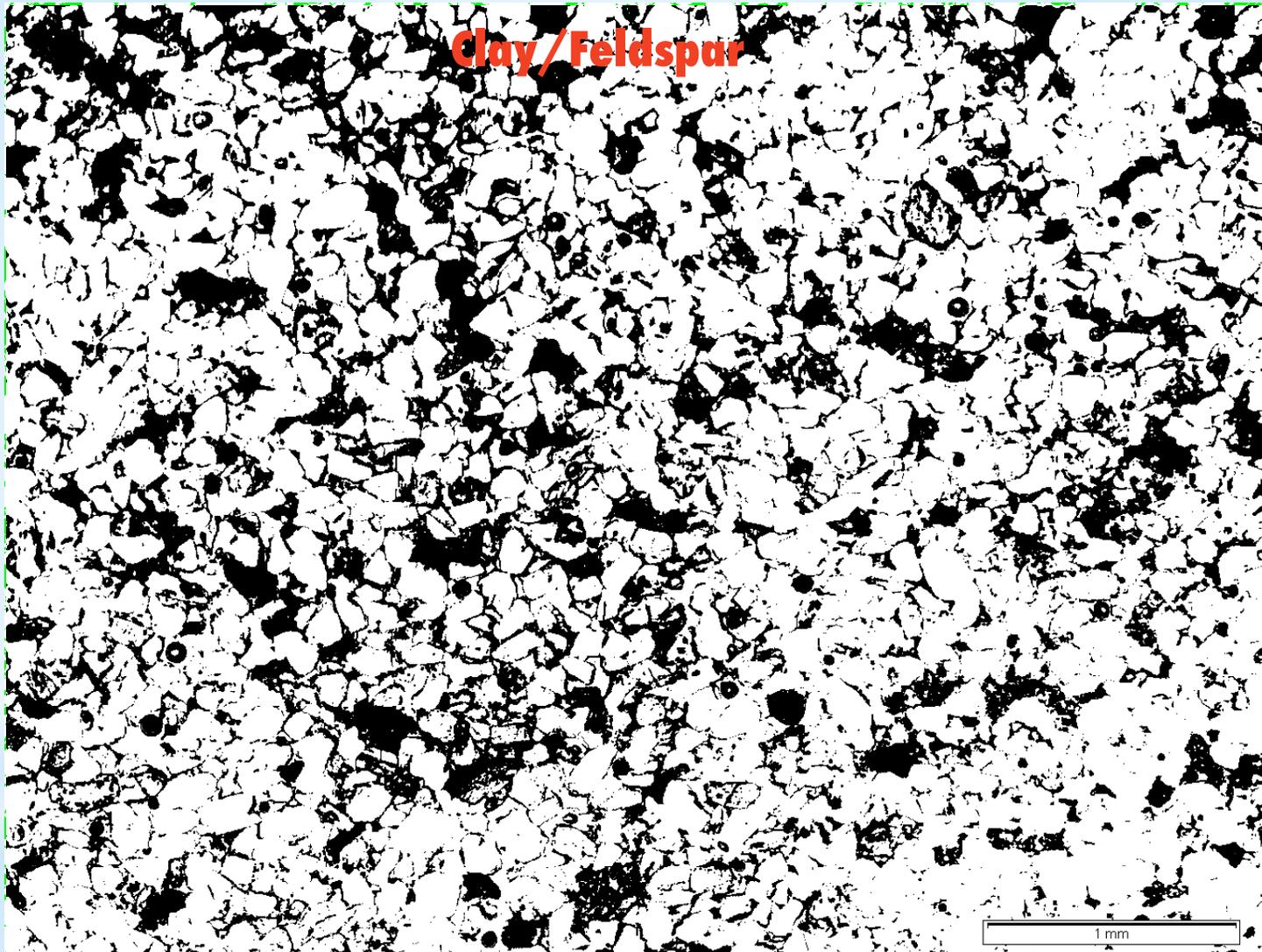


Depth 6950

ϕ 20.2%
Kv 390.4 mD

- Large pore throats
- Good interconnectivity
- Feldspar dissolution

Lower Mt. Simon Petrography



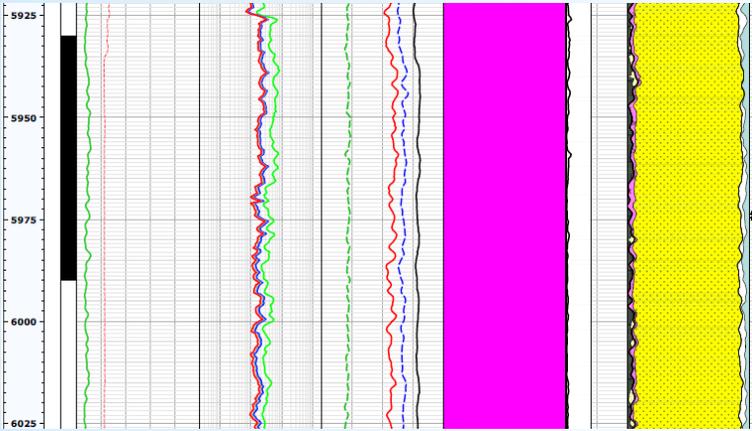
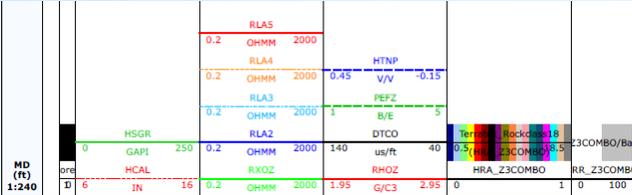
Depth 6701

ϕ 26.6%

Kv 77.0 mD

- Abundant pore space
- Abundant clay minerals in pore throats

Middle Mt. Simon



- Fine to very fine-grained sandstone
- Well cemented with quartz and hematite
- Potential internal seal

Middle Mt. Simon Depositional Environment

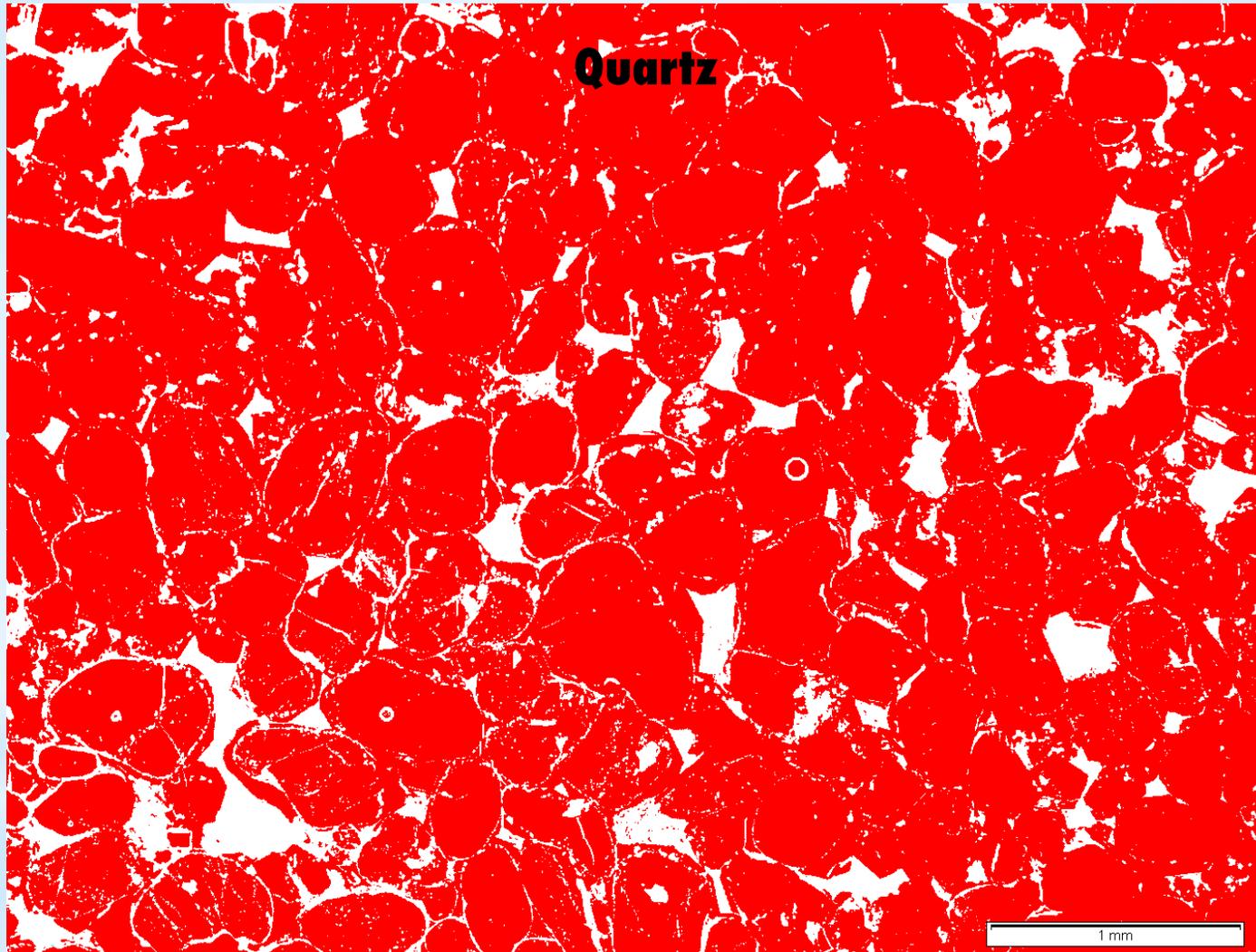
- Fluvial-Shallow braided river system on playa
- Eolian-Interdune-Playa

Characterized by:

- Fine to very fine grain, ripple to planar laminated, cross-bedded, and mottled sandstone (Fluvial)
- Fine to very fine grain, planar to ripple laminated with adhesion ripples and mottled sandstone (Eolian)



Middle Mt. Simon Petrography



Depth 5972

ϕ 8.5%

Kv 1.1 mD

- Quartz cement
- Isolated pore space
- Trace feldspars

Upper Mt. Simon Depositional Environment

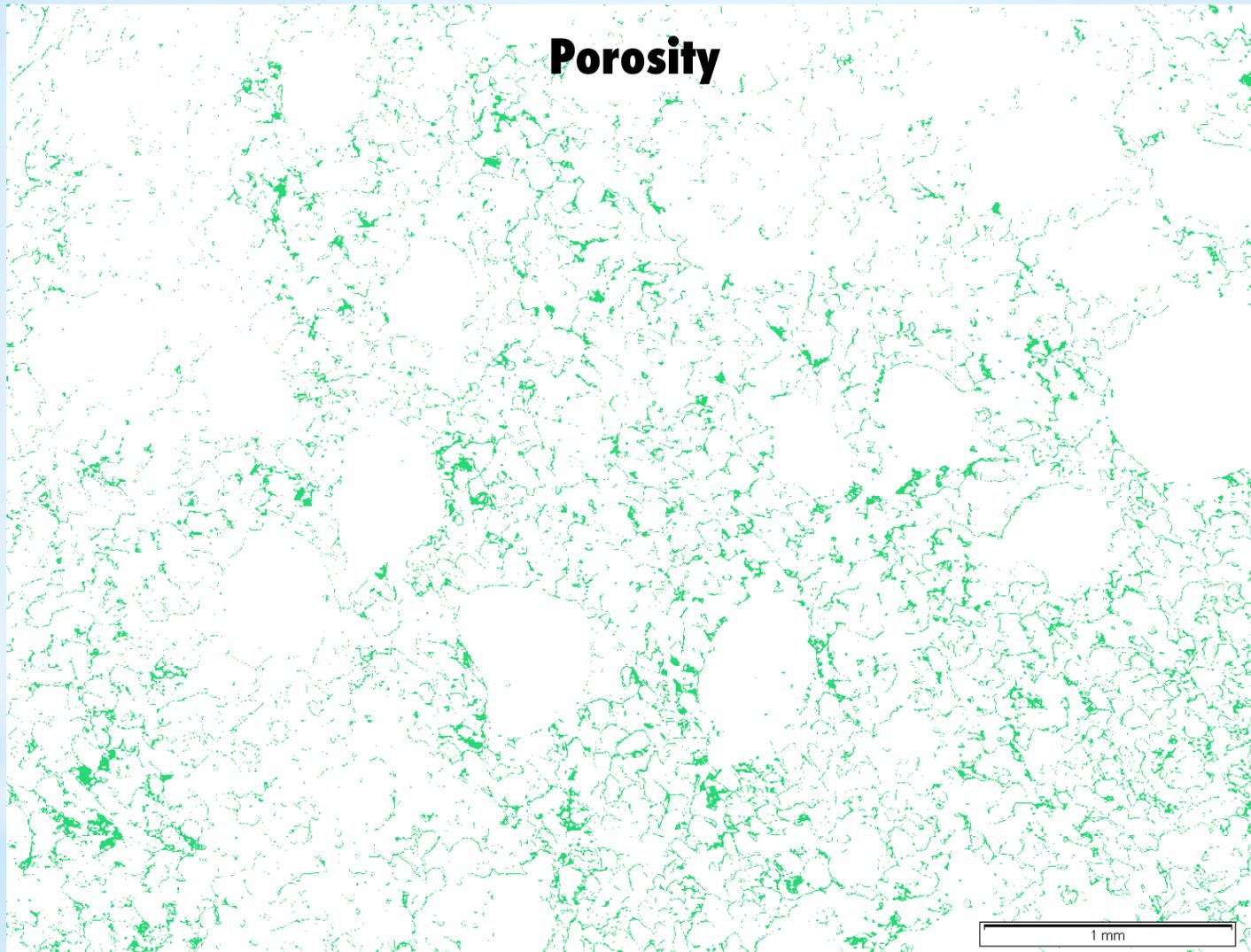
- Tidal Flats
- Tidal Channels

Characterized by:

- Fine to silty grained, interstratified, wavy laminated, mottled, and bioturbated siltstones and sandstones. Tidal rhythmites common (Tidal Flat).
- Fine to coarse grained cross-bedded, planar laminated, interstratified sandstones (Tidal Channel).



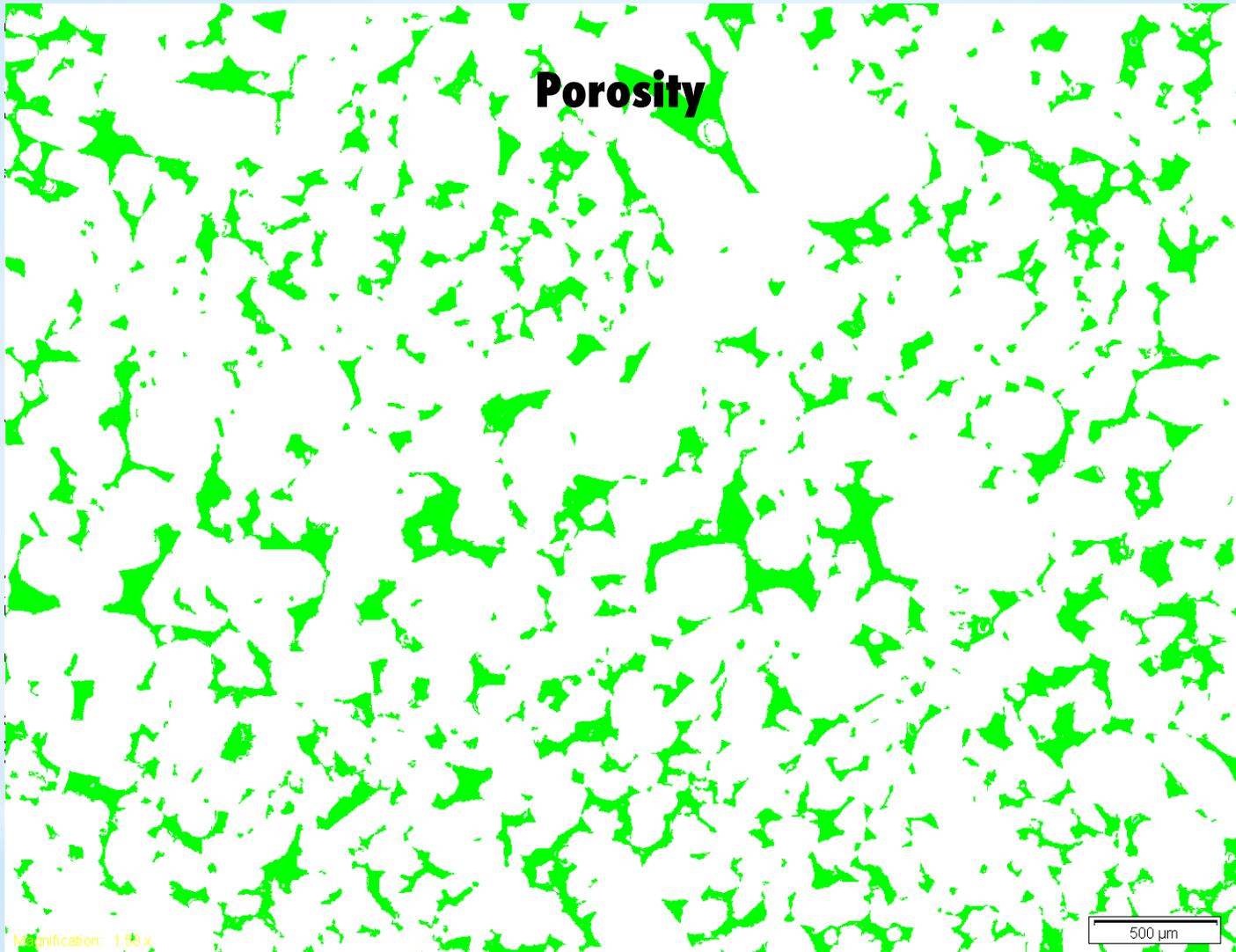
Upper Mt. Simon Petrography



Tidal Flat
Depth 5528'

ϕ 5.5%
Kv <.01 mD

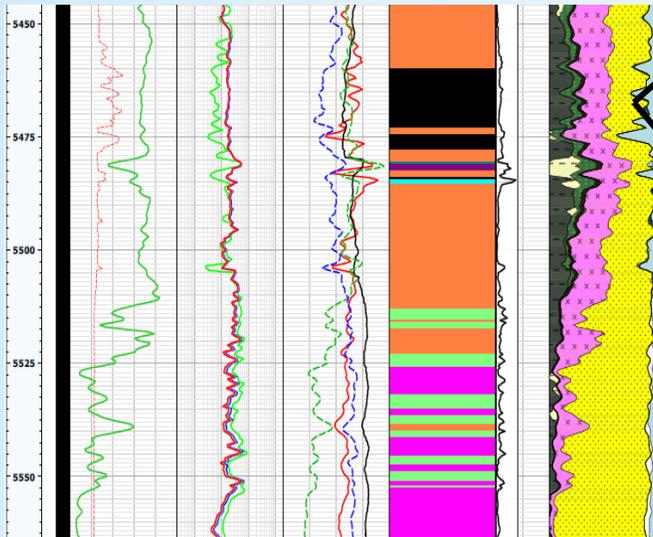
Upper Mt. Simon Petrography



Tidal Channel
Depth 5648'

ϕ 16.4%
K 237.5mD

Eau Claire Formation



- The lower 300 feet is dominantly mudstone with interbedded, siltstone, and sandstone



An Excellent Seal!

Eau Claire Depositional Environment

- Shallow Marine (upper shoreface to offshore below storm wave base)

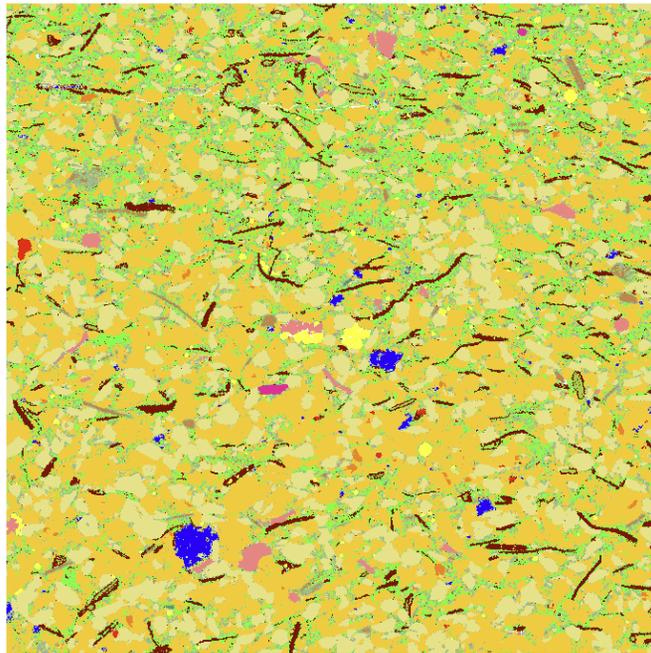
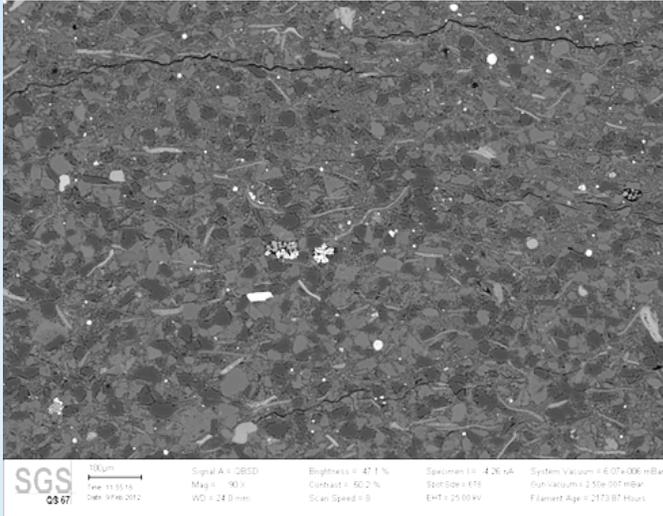
Characterized by:

- Interstratified, planar laminated and wavy bedded siltstone, very fine sandstone, and mudstone. Commonly bioturbated



Eau Claire Petrography

Quantitative Evaluation of Minerals by Scanning Electron Microscopy (QEMSCAN)



Area %

43.2

K Feldspar

22.2

Quartz

18.7

Fe-Illite & illite-smectite

7.6

Illite & illite-smectite

4.8

Biotite

0.9

Apatite

0.6

Pyrite

0.3

Chlorite

0.3

Ferroan Dolomite

No Porosity

Conclusions

- The Lower Mount Simon maintains excellent framework porosity and secondary porosity resulting from feldspar dissolution. However, permeability is sometime occluded by diagenetic clays
- The Middle Mt. Simon is a potential internal seal due to presence of fine grains and diagenetic cements such as quartz and hematite
- The Upper Mt. Simon has good reservoir properties along with internal baffles due to tidal deposited clayey siltstones and sandstones
- The overlying Eau Claire formation is dominated by clay rich siltstones and mudstones resulting in an excellent seal for the Mt. Simon reservoirs