

# Geochemical and Petrophysical Characterization of the Bakken Shale in Mountrail County, North Dakota

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# Outline

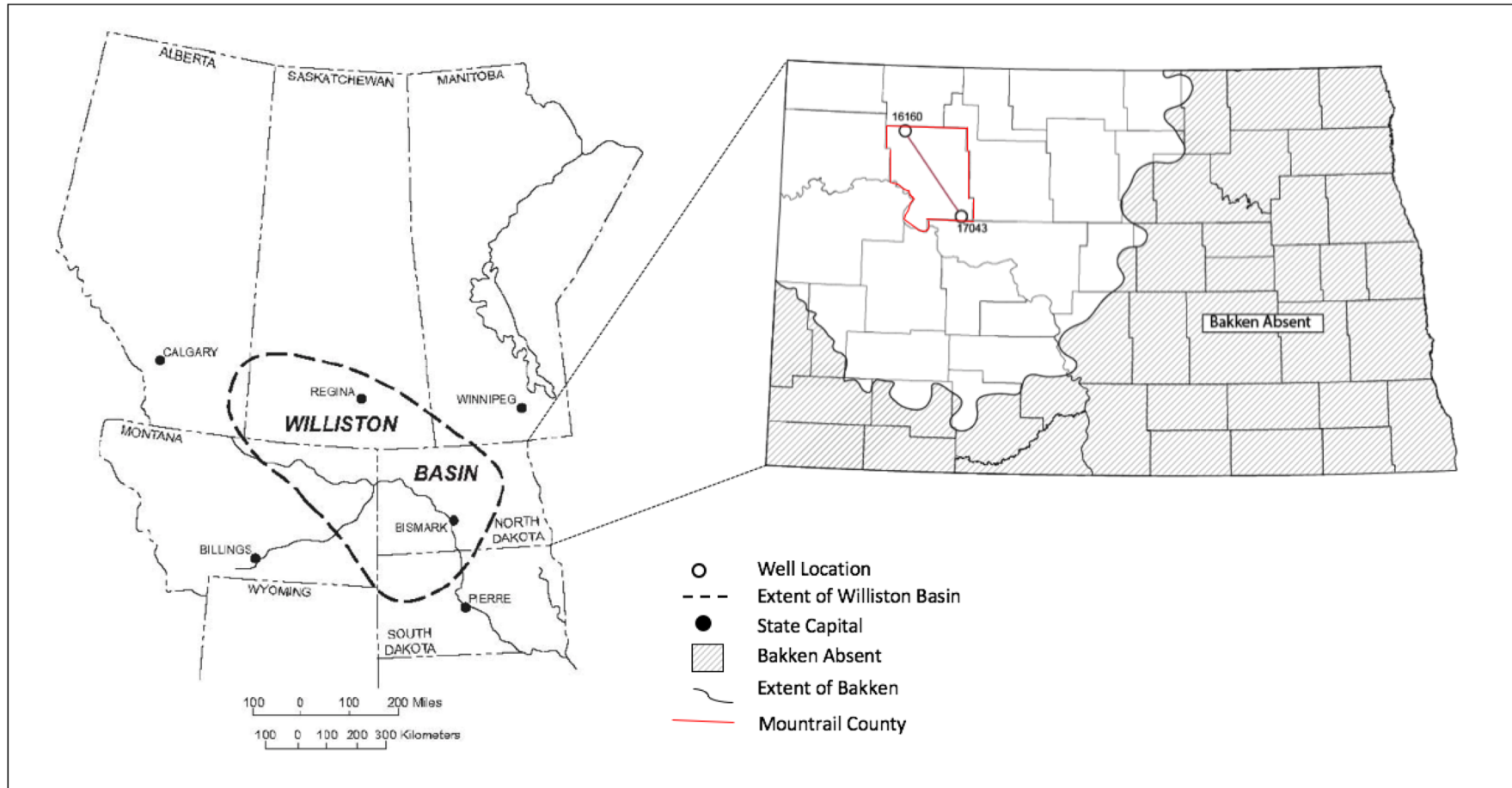
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- Introduction
  - Motivation
  - Study Area
- Methods
  - Source Rock Analysis
  - Scanning Electron Microscope
  - X-ray Diffraction
  - Nuclear Magnetic Resonance
- Results
- Conclusions

# Motivation

- Bakken Formation is one of the most prolific tight plays in the Williston Basin. However, due to its heterogeneity and very low porosity and permeability, the Bakken recovery factors remain small (5%-10%).
- The Bakken Petroleum System consist of source rocks that have been buried to depths and temperatures that have generated significant volumes of oil (million barrels of 42 API gravity )
- Connected matrix related pores alongside a fracture form flow pathway network

# Study Area



2 wells Mountrail County

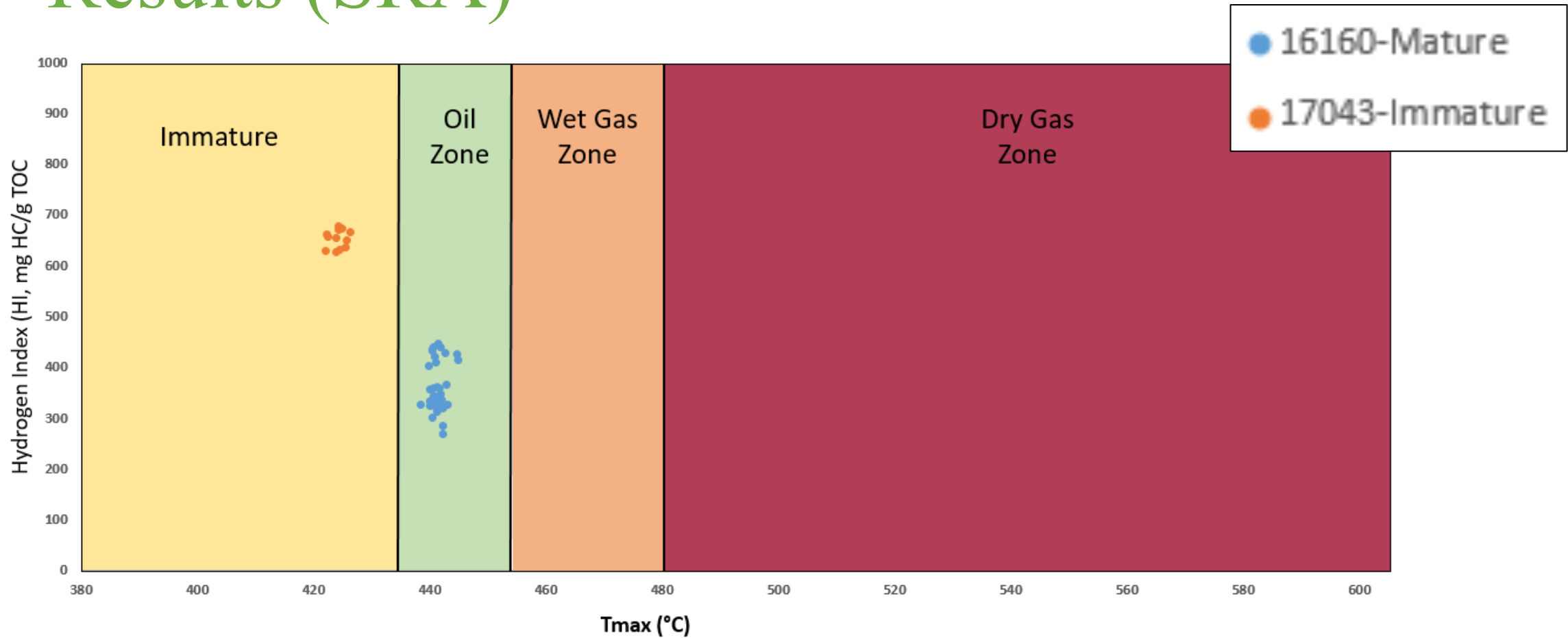
NDIC No	Depth to Bakken (ft)
17043	9072
16160	9511



# Methods

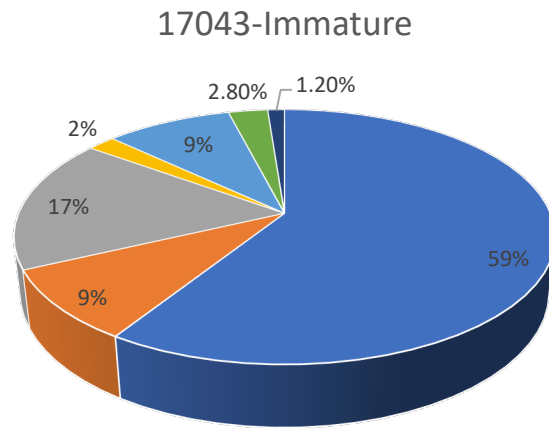
- *Source Rock Potential and Maturity*
- *Scanning Electron Microscope Analysis*
- *X-ray Diffraction*
- *Nuclear Magnetic Resonance Analysis*
  - *Scan sample*
  - *Evacuate air*
  - *Saturate sample (Nacl brine)*

# Results (SRA)

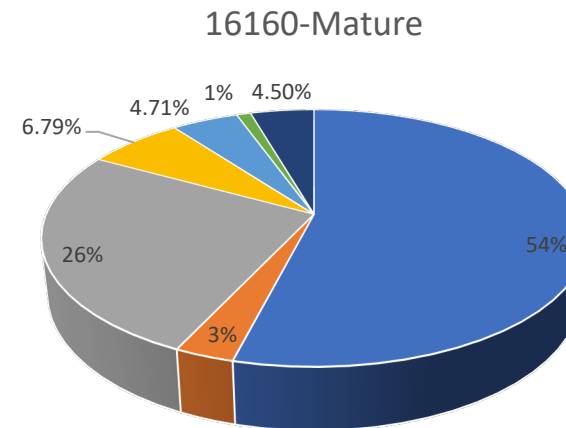


Plot of HI vs Tmax showing maturity

# Results (XRD)



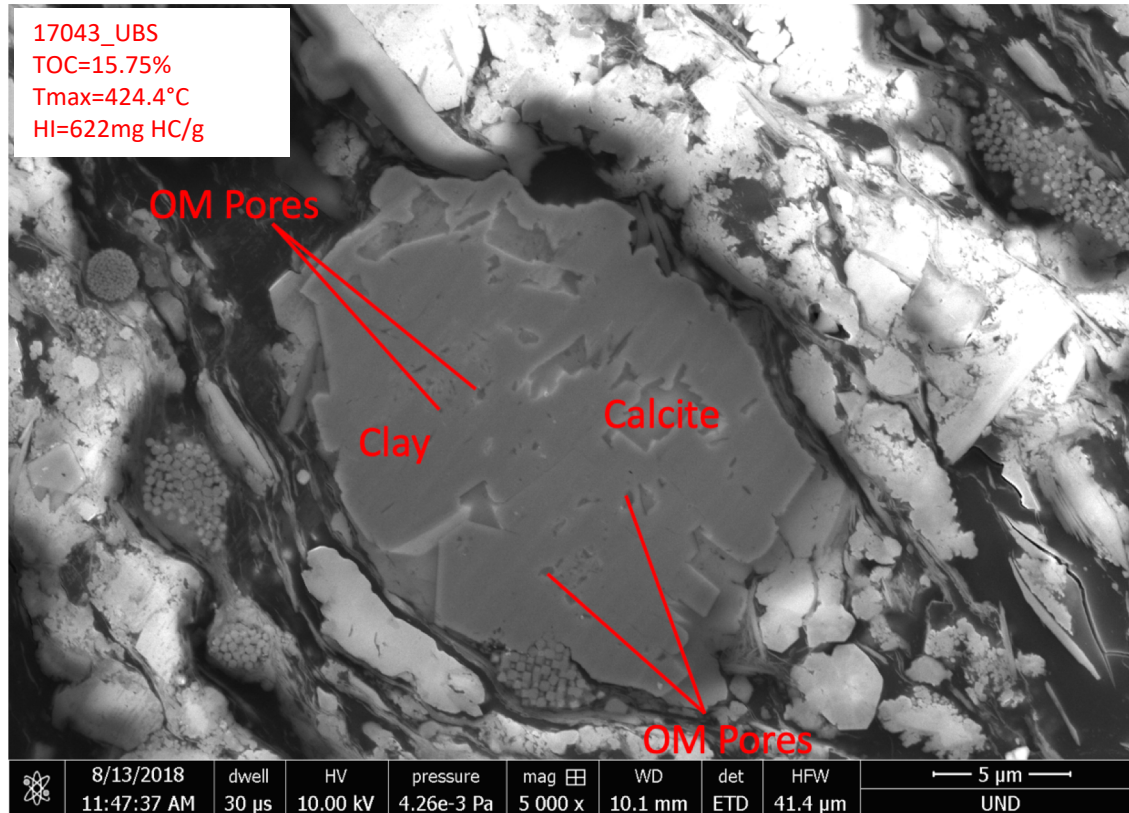
■ Quartz ■ Pyrite ■ Muscovite ■ Microcline ■ Phlogopite ■ Chlorite ■ Gypsum



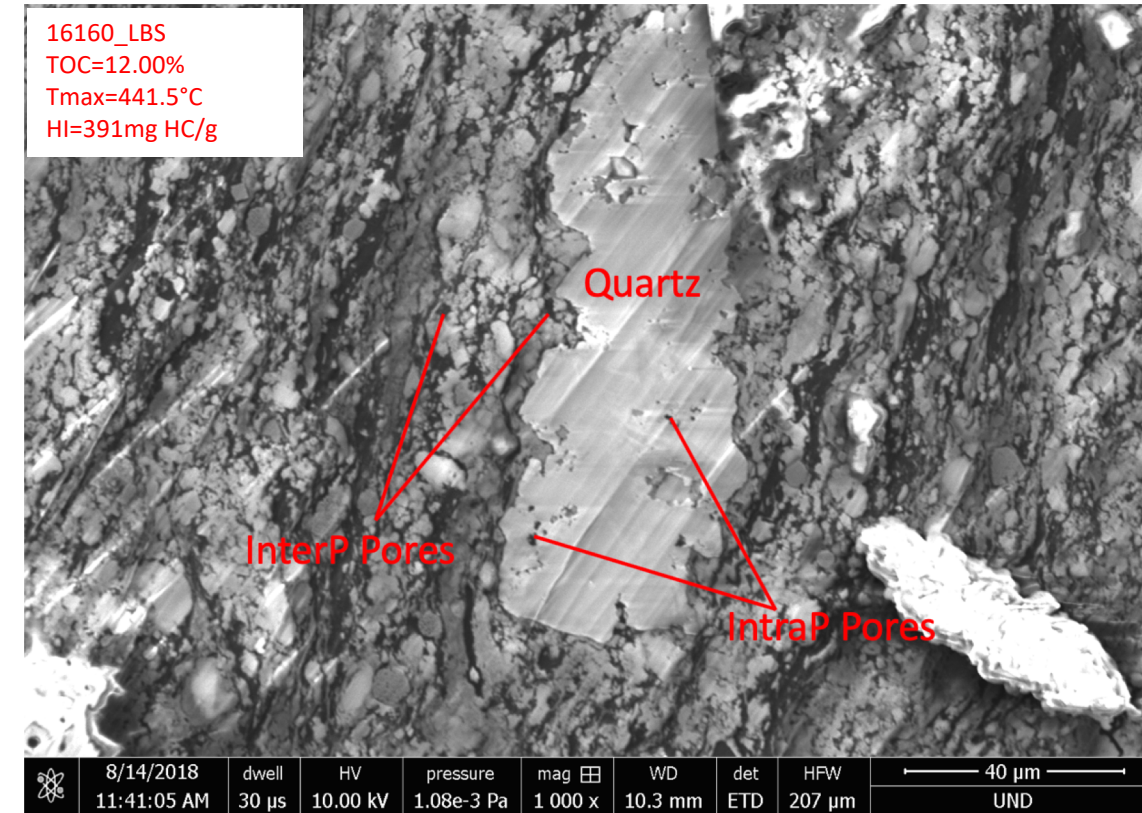
■ Quartz ■ Pyrite ■ Aluminoceladonite ■ Sanidine ■ Chlorite ■ Apatite ■ Illite

- Immature well has higher content of pyrite than the mature sample
- Mature sample has high content of clay mineral than the immature sample

# Results (SEM)



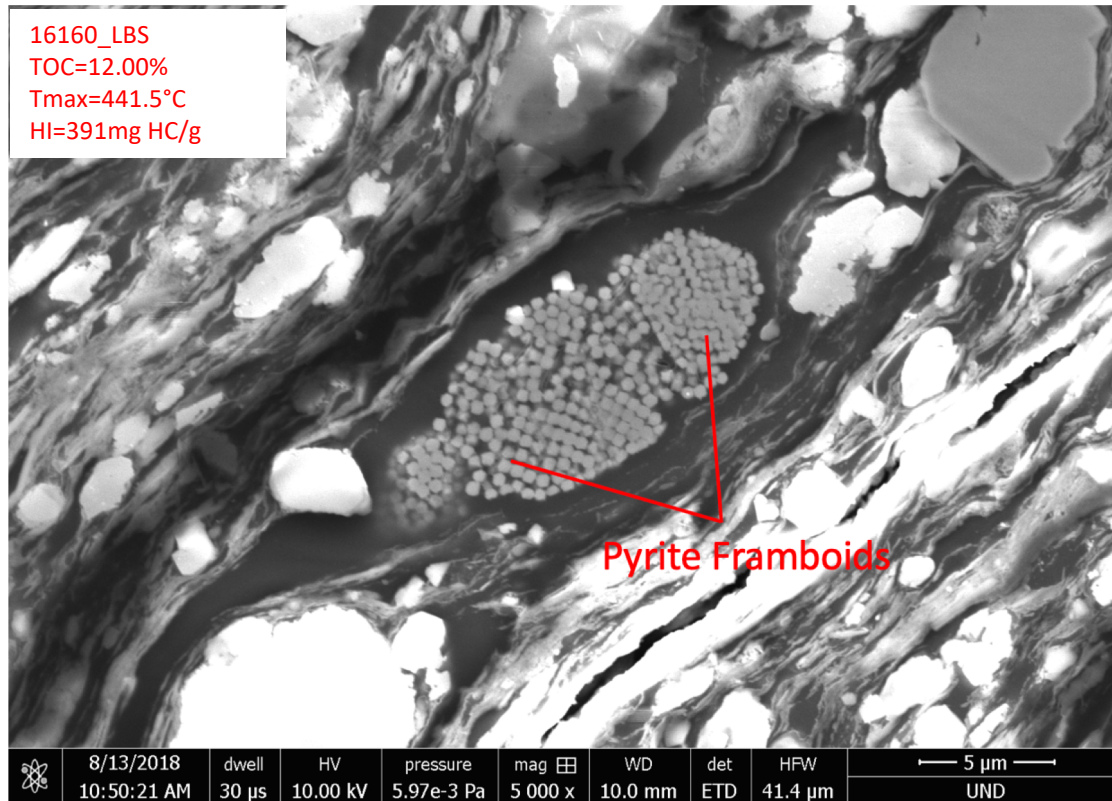
Example of Organic Matter (OM) Pores



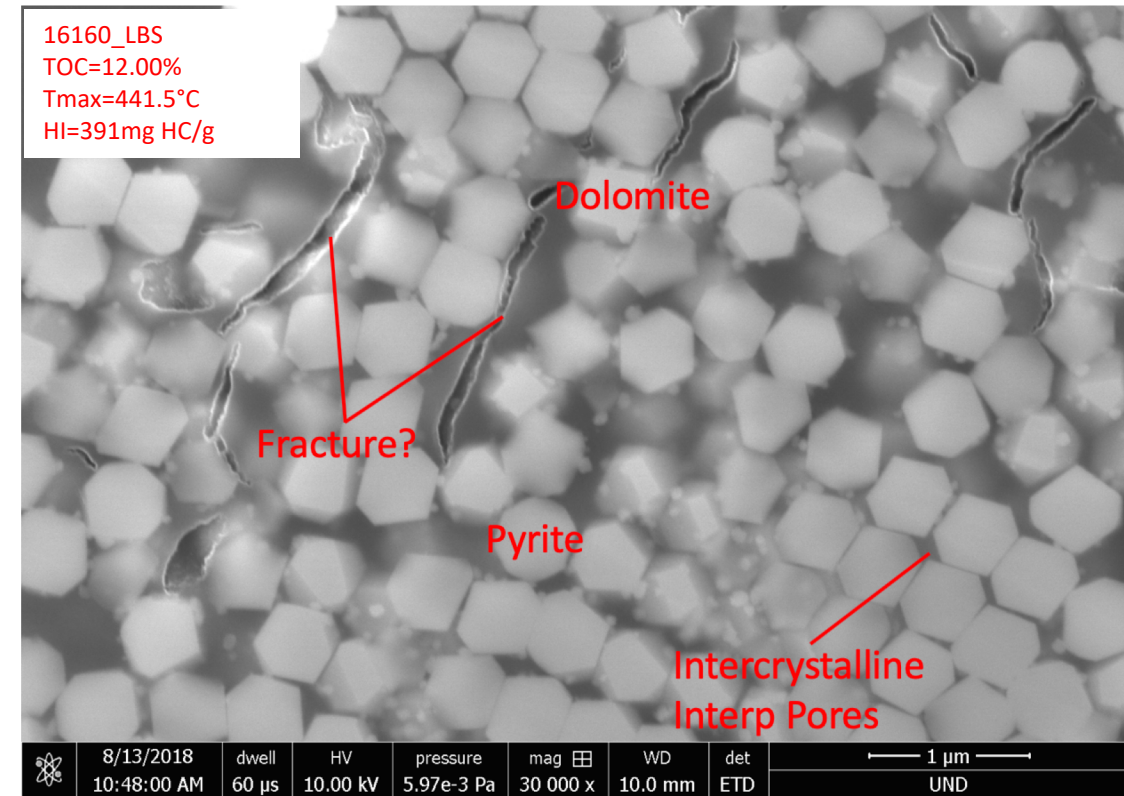
Example of Mineral matrix (interparticle and intraparticle) Pores



# Results (SEM)

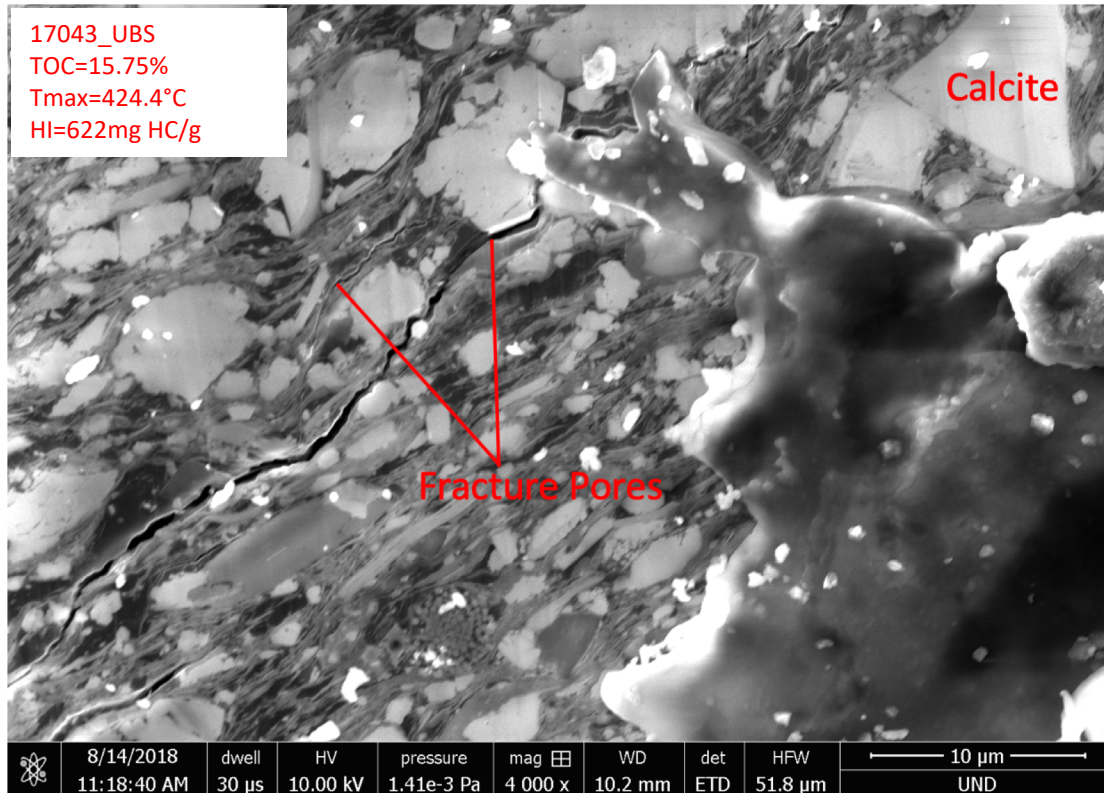


Pyrite Framboids

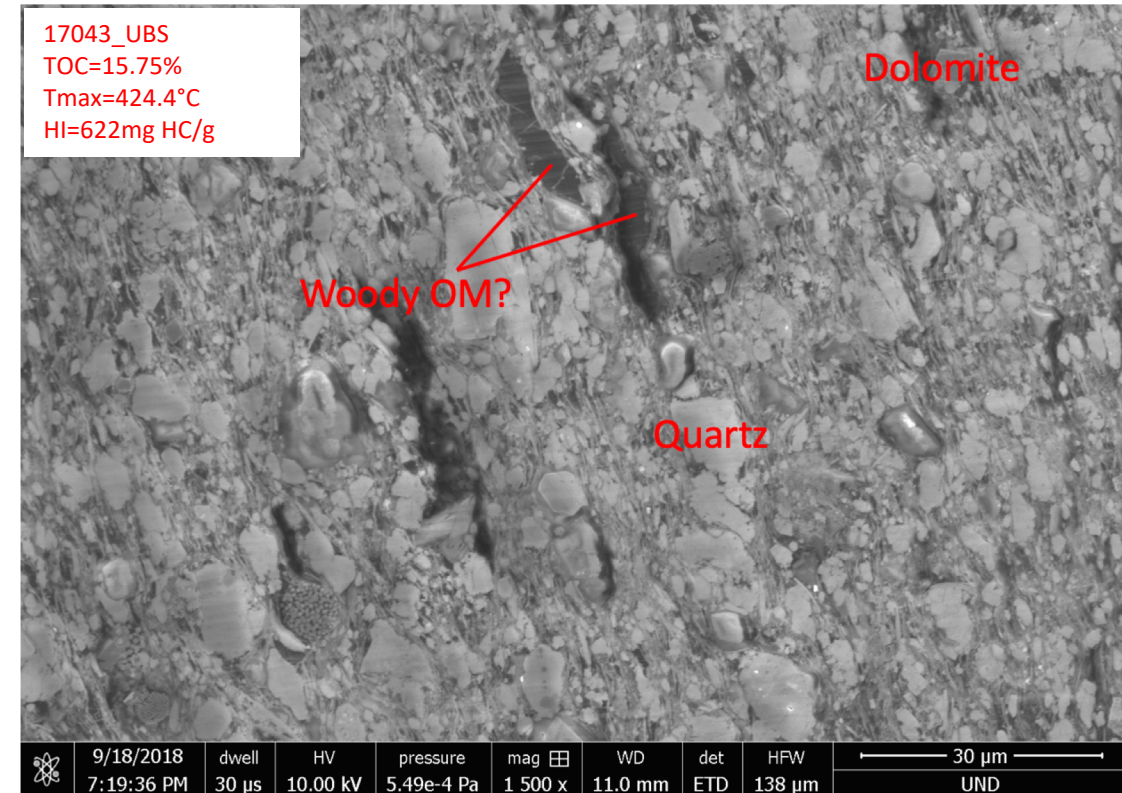


Close-up image of the pyrite framboids showing fractures?

# Results (SEM)



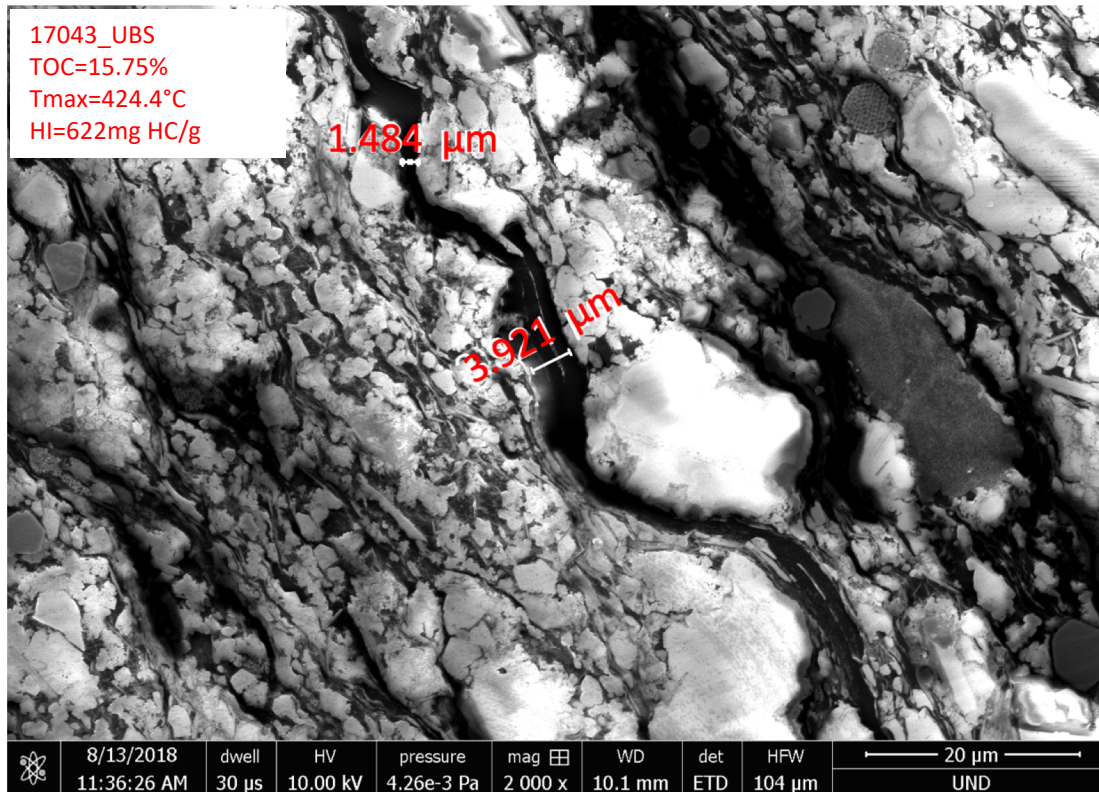
Fracture Pores



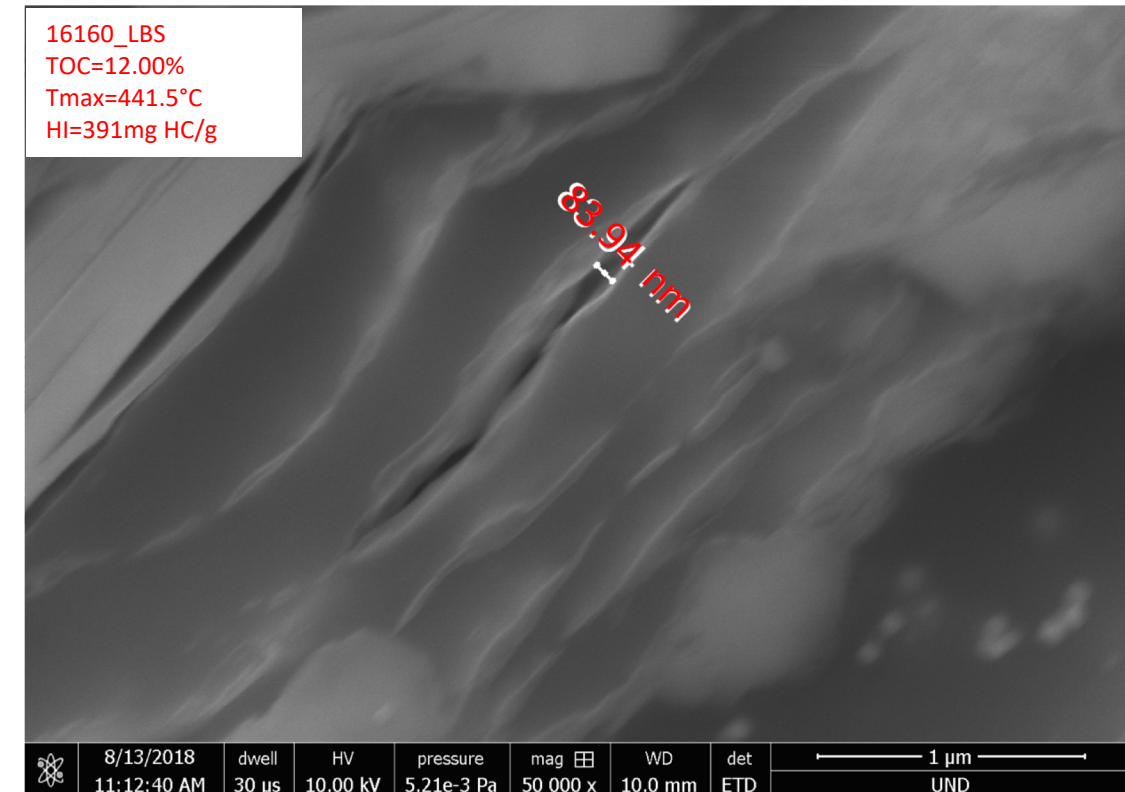
Woody Organic Matter?



# Results (SEM)

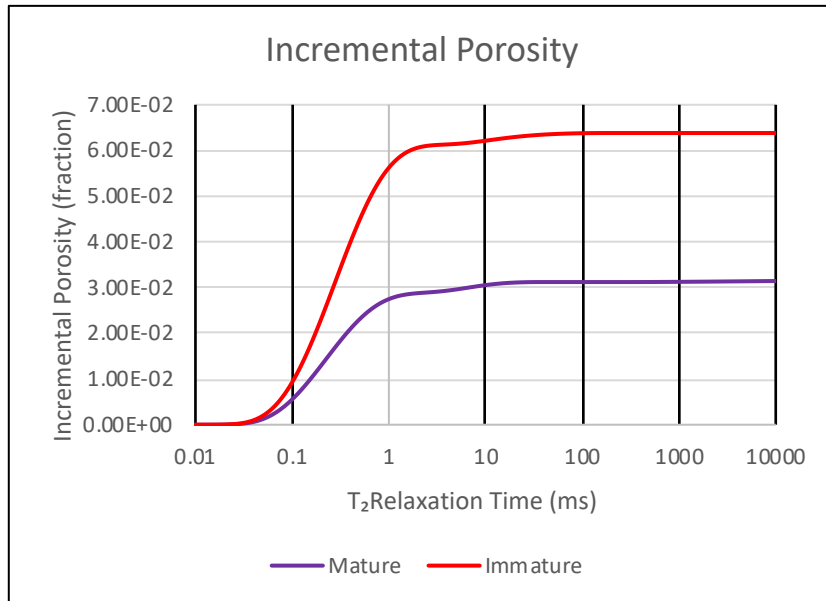


Size of pores within the immature sample

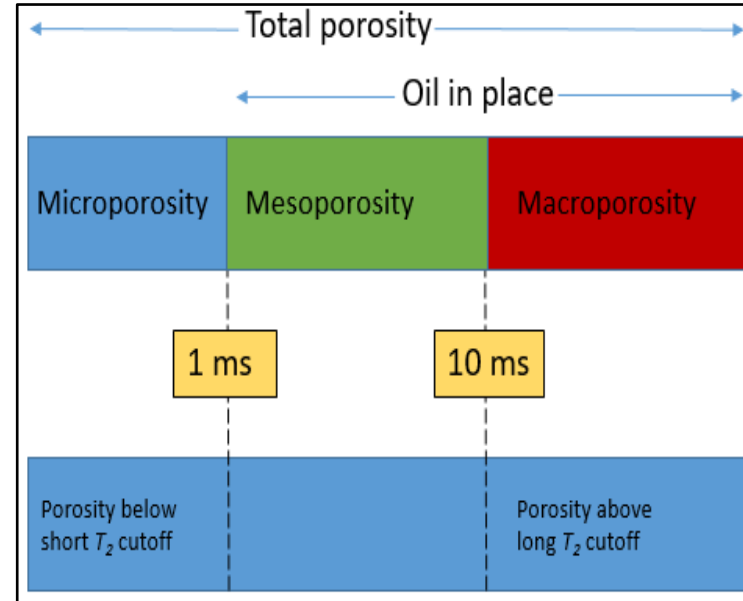


Size of pores within the mature sample

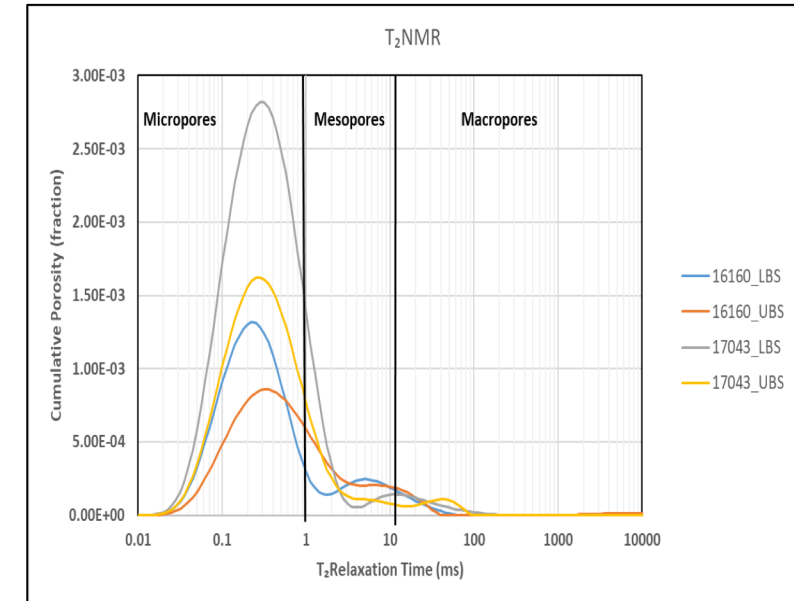
# Results (NMR)



$T_2$  Relaxation Time Vs Incremental Porosity



NMR porosity partitioning based on  $T_2$  cutoffs. Adapted from Green and Veselinovic (2010)



Porosity portioning for all tested sample

# Conclusions

- Excellent source rock (12.00 to 15.75 wt%).
- Immature sample with highest TOC content (15.75 wt.%) has more organic porosity.
- Three pore types are found within Bakken Shales (mineral matrix, organic matter and fracture pores)
- The pore types were controlled by properties individual mineral within the samples
- Bakken source rocks are comprised of mainly nanometer to micrometer pore sizes.

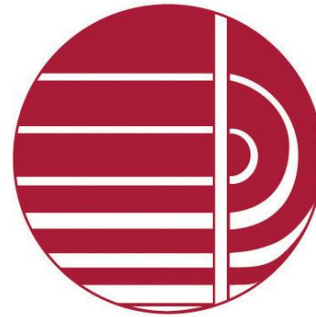
# Future Work

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- Analyze more wells in the Williston Basin
- NMR logs

# Acknowledgement

- Special thanks to North Dakota Geological Survey (NDGS) and Energy & Environmental Research Center (EERC)



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# Questions?



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