



**UNCONVENTIONAL RESERVOIR ENGINEERING PROJECT**  
**COLORADO SCHOOL OF MINES**



## Pore/Molecular-Scale Measurements

# INTERPRETATION OF PORE SIZE DISTRIBUTION OF THE NIOBRARA SHALE \*

Asm Kamruzzaman

PhD Student

Petroleum Engineering Department

Colorado School of Mines

\*Covers works from my MS research at CSM under Dr. Manika Prasad



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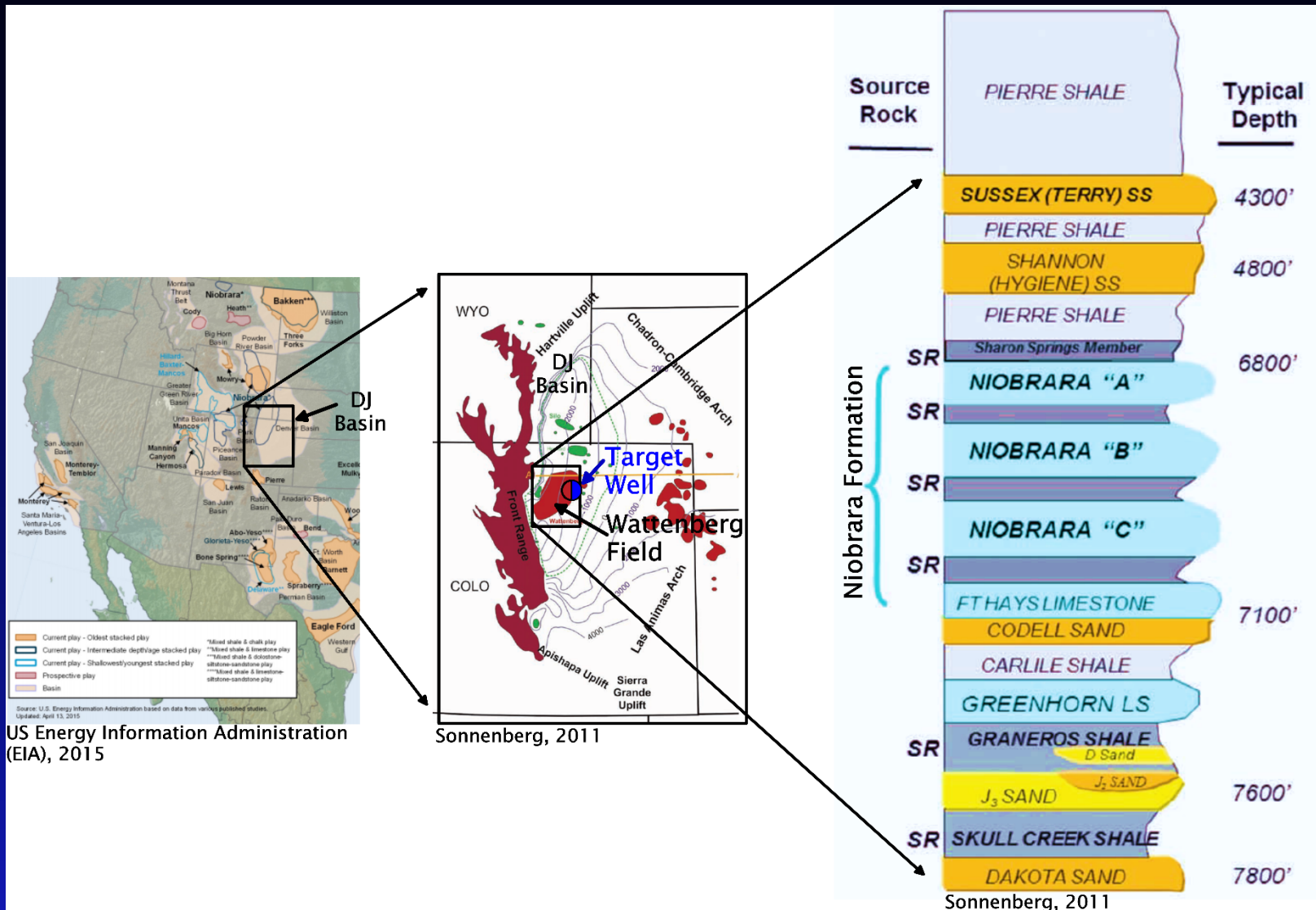
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# Presentation Outline

- Overview of the Niobrara Formation
- Niobrara lithofacies classification
- Porosity measurement methods
- Shale matrix: a nanoscopic world
- Types of pores in shale matrix
- N<sub>2</sub> pore size distribution vs. clay content
- N<sub>2</sub> pore size distribution vs. toc content
- N<sub>2</sub> porosity vs. specific surface area (SSA)
- Experimental study of nanoscale flow and phase behavior



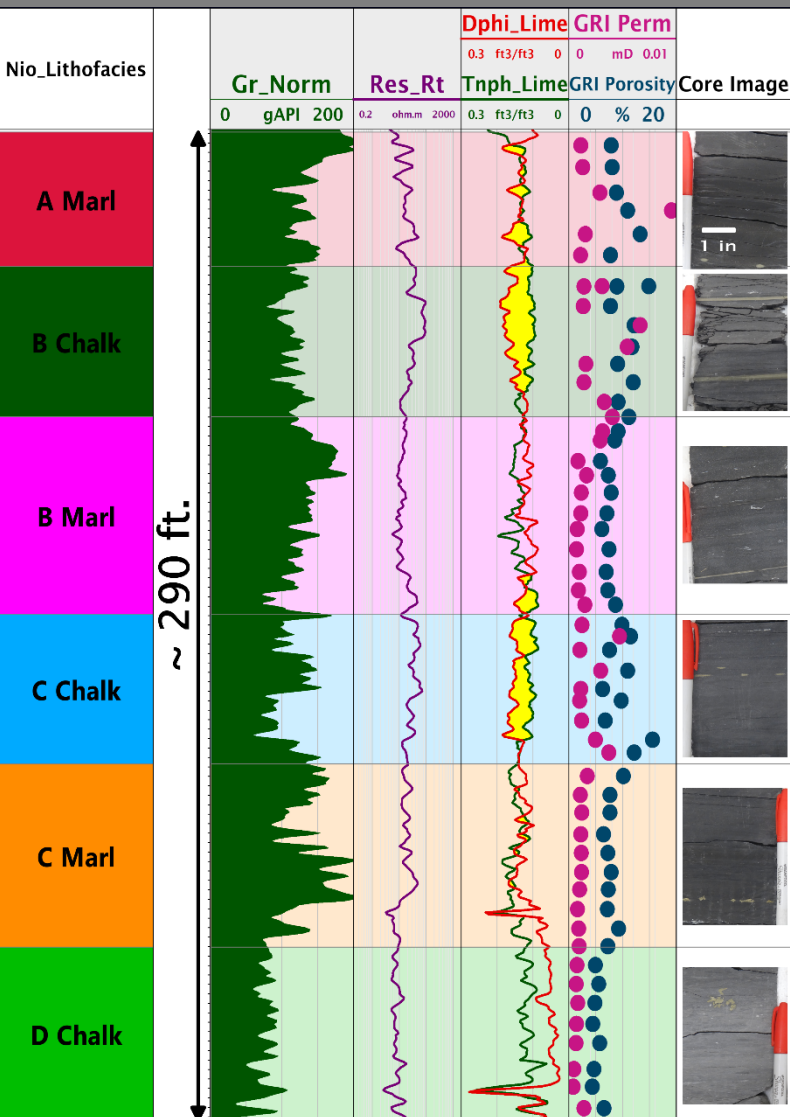
# Overview of the Niobrara Formation



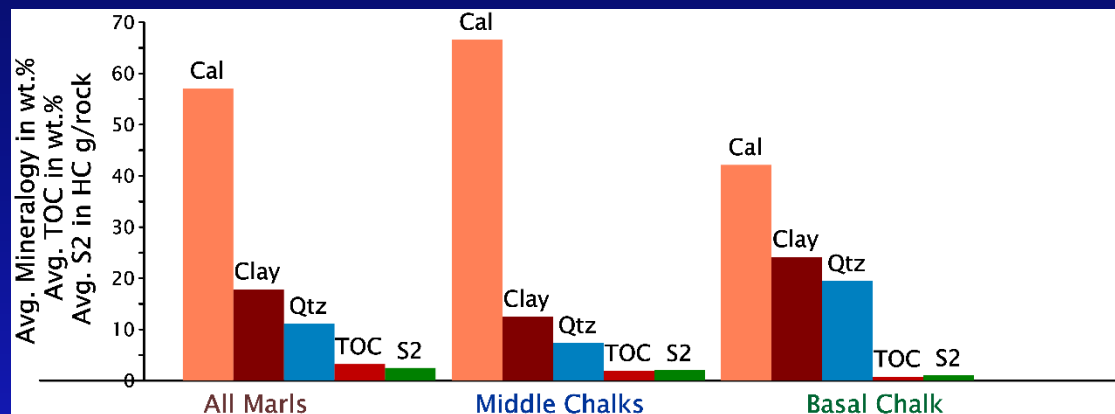
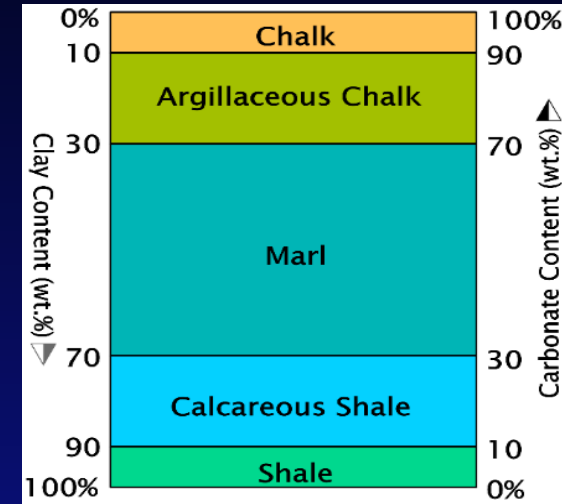
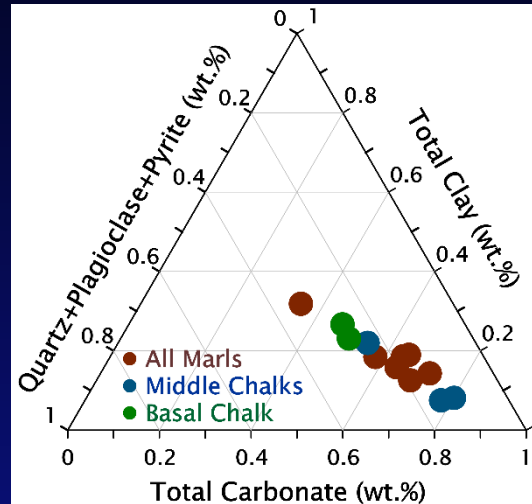
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# Niobrara Lithofacies Classification



Lithology interpretation scheme by Sonnenberg (2011)



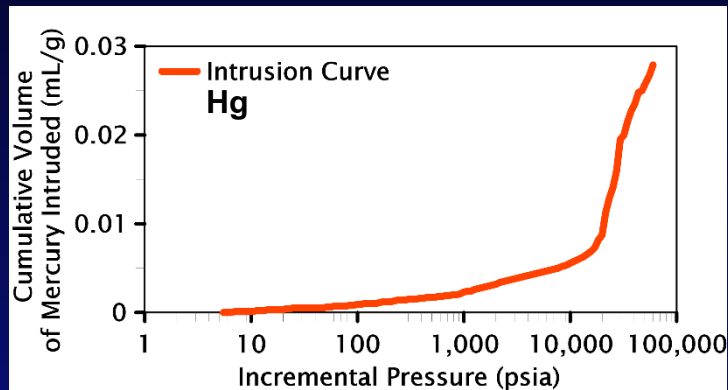
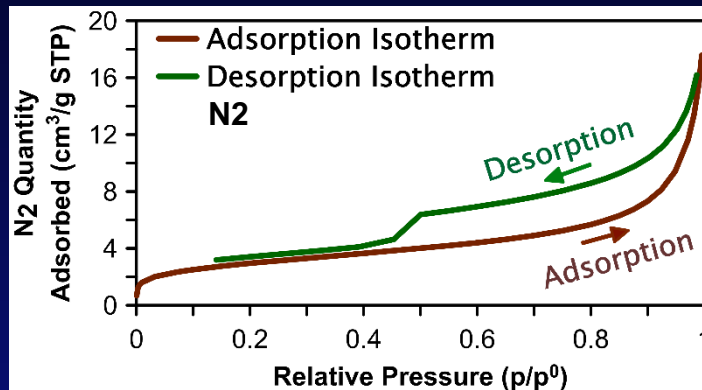
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# Porosity Measurement Methods

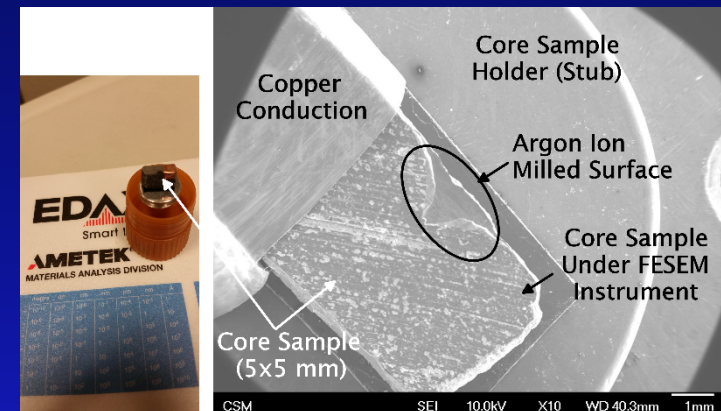
## Porosity Measurement Techniques

- N<sub>2</sub> gas adsorption; mercury intrusion capillary pressure (MICP)
- Porosity, pore type, pore size distribution (PSD), pore-throat size distribution (TSD)
- Pore geometry and fluid flow path



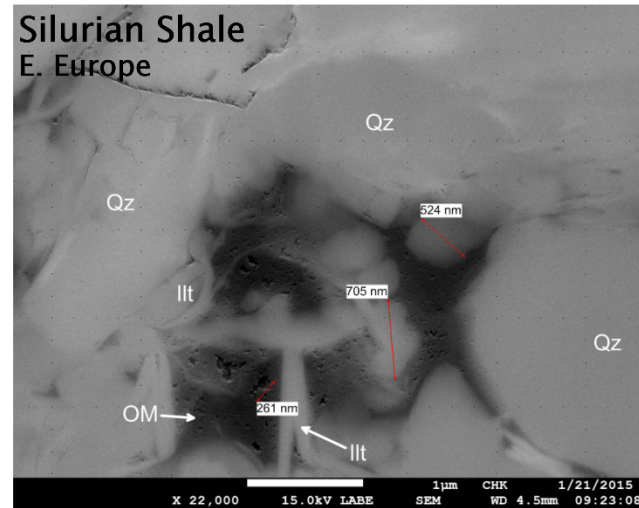
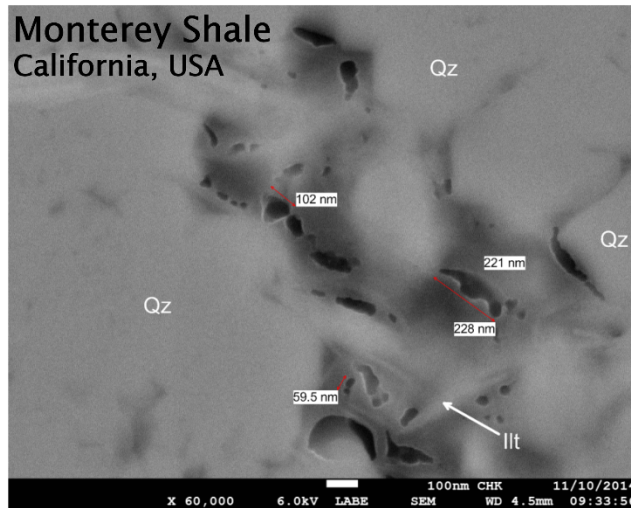
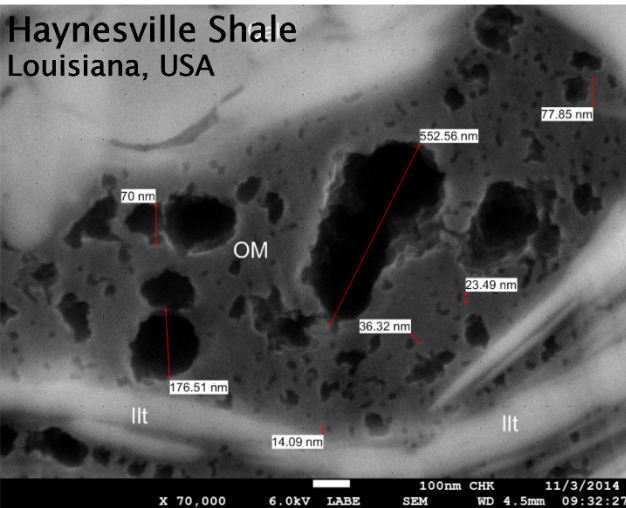
## Nanoscale Imaging Techniques

- Field emission scanning electron microscopy (FESEM)
- Identify minerals
- Measures pores, pore geometry





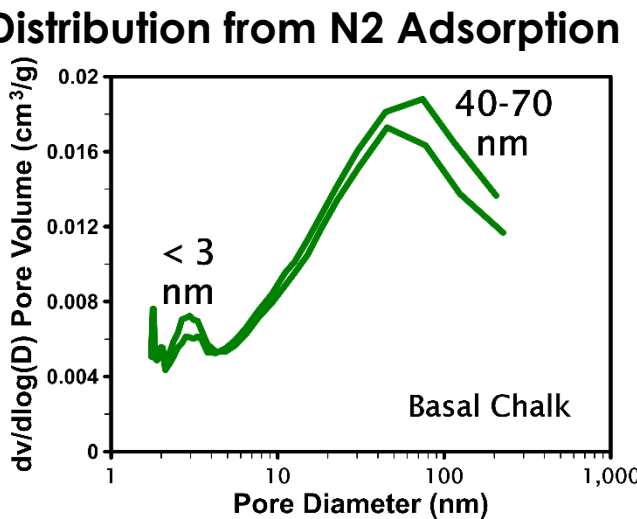
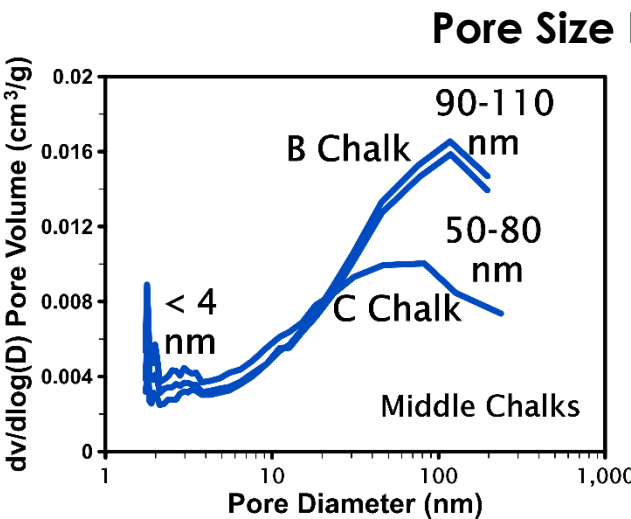
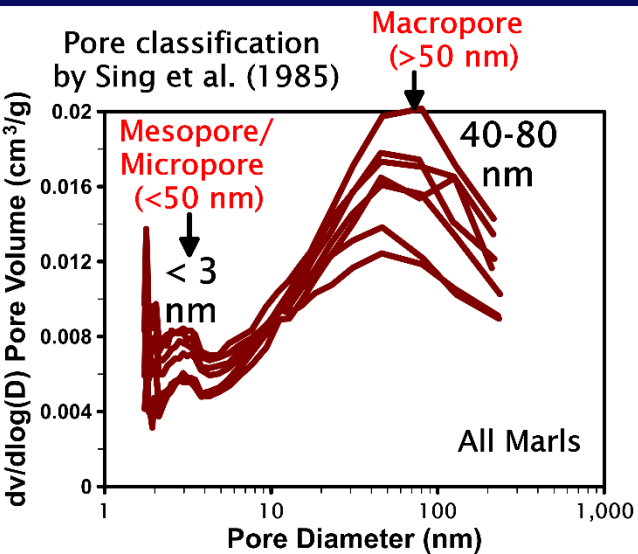
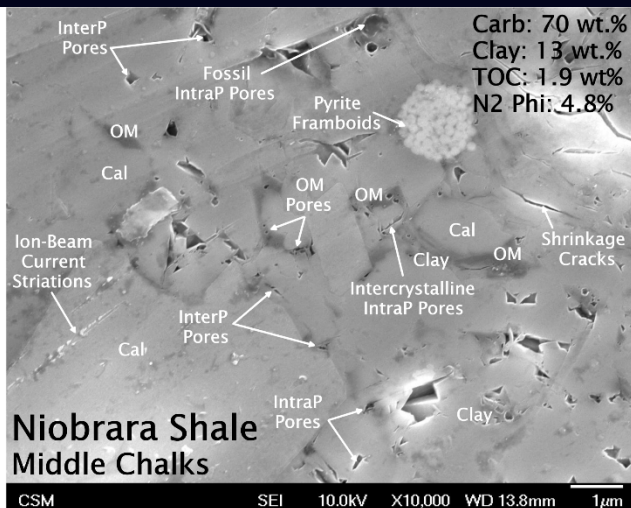
# Shale Matrix: A Nanoscopic World



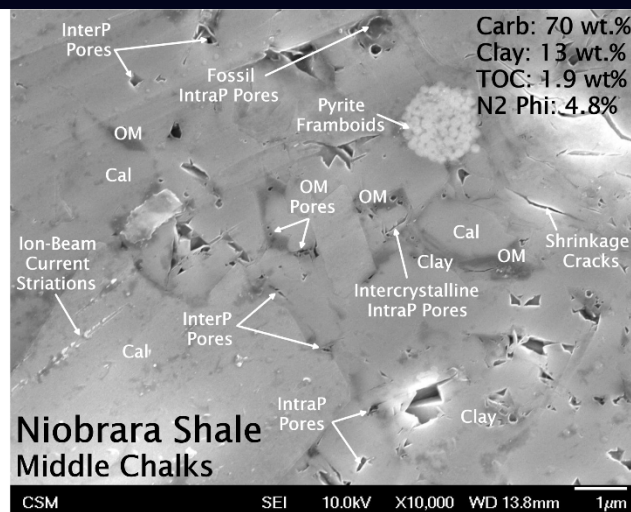
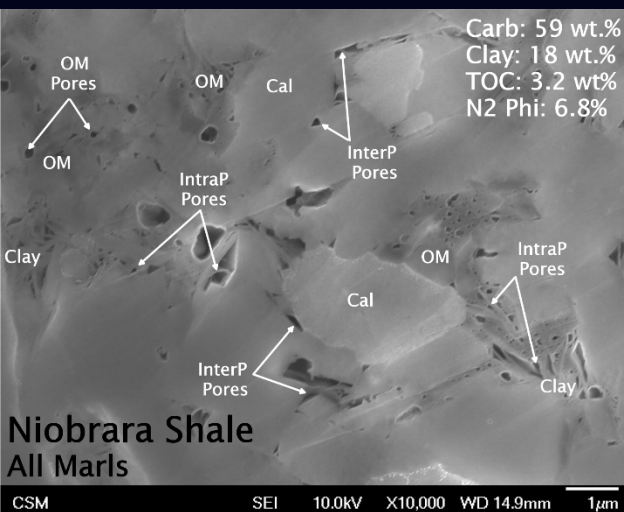
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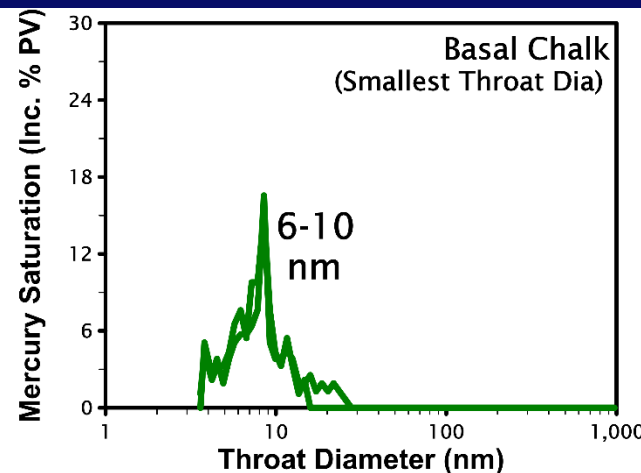
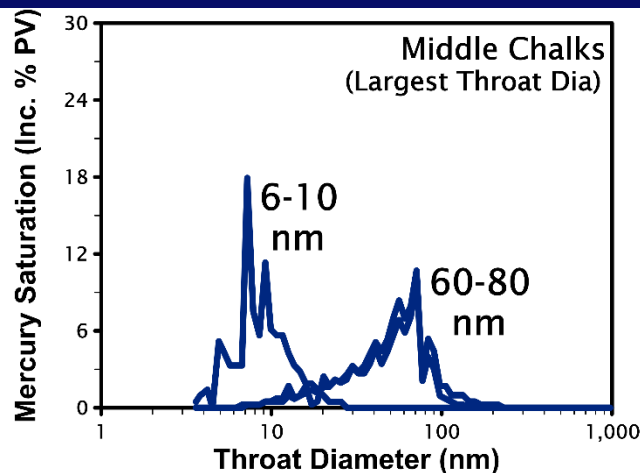
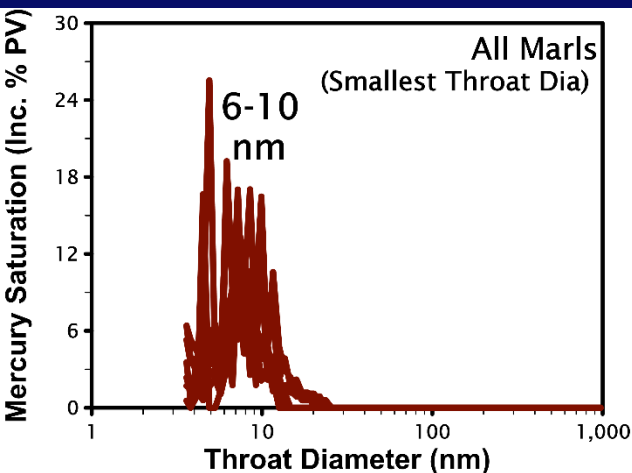
# Types of Pores in Shale Matrix



## Types of Pores in Shale Matrix cont.

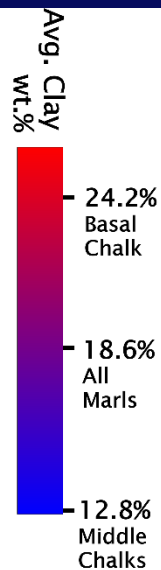
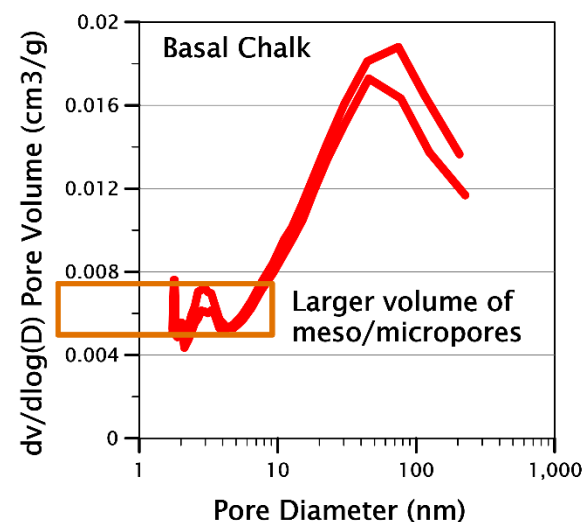
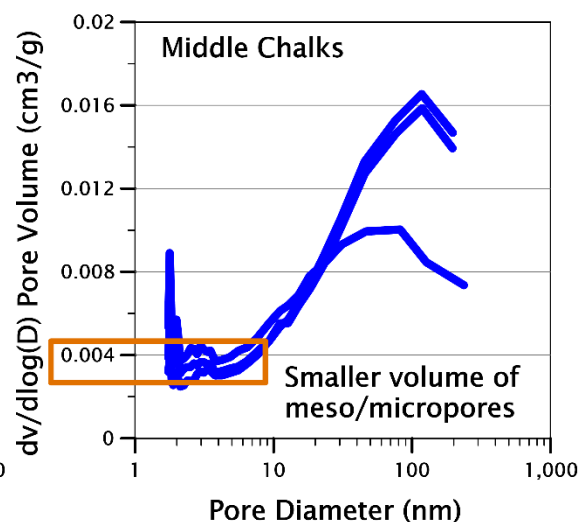
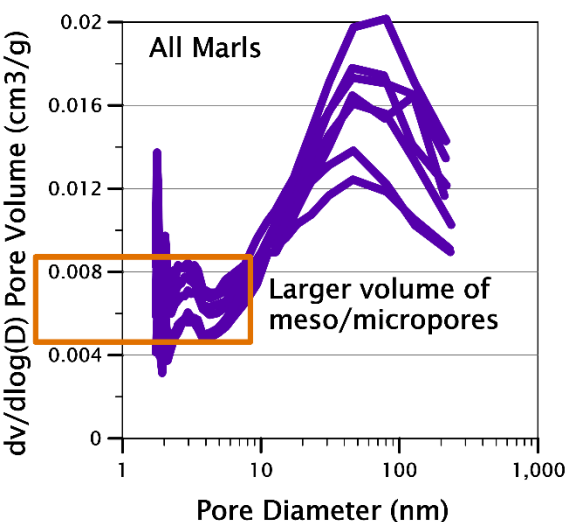
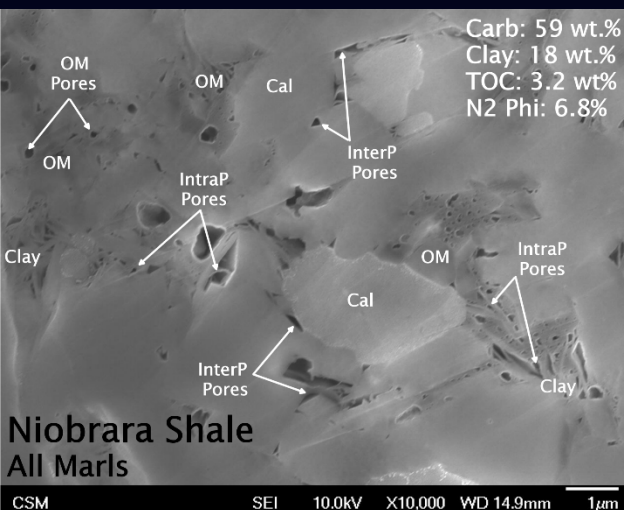


## Pore-Throat Size Distribution from MICP





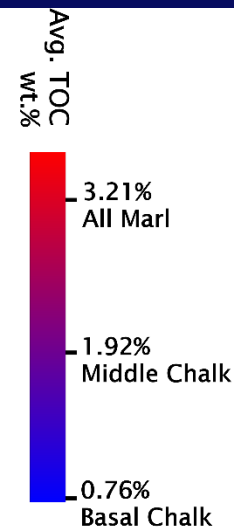
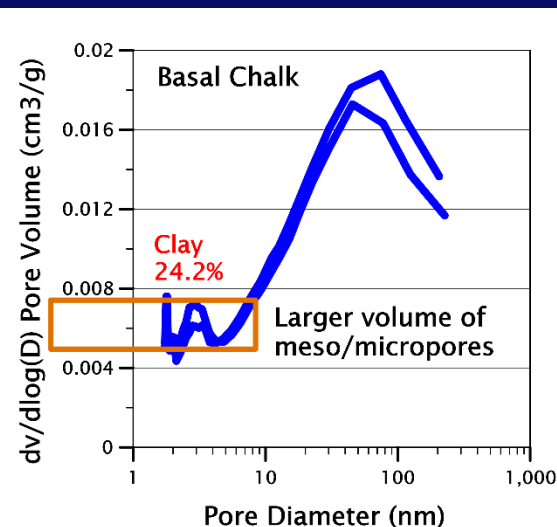
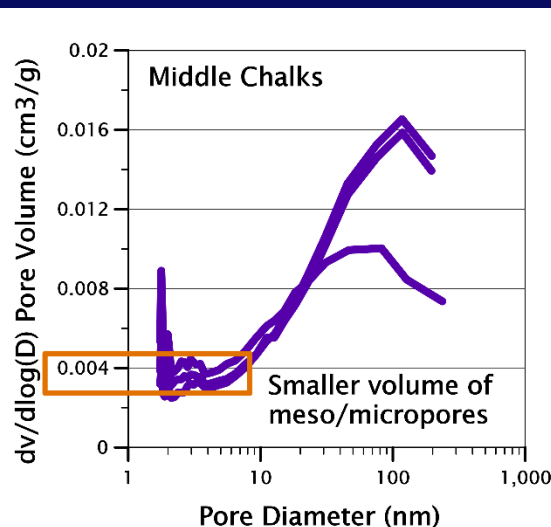
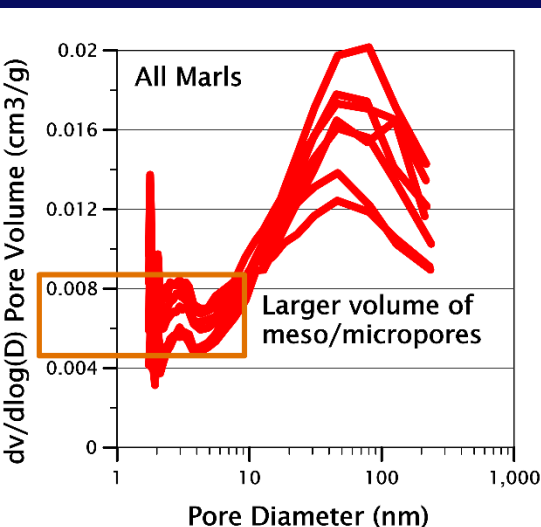
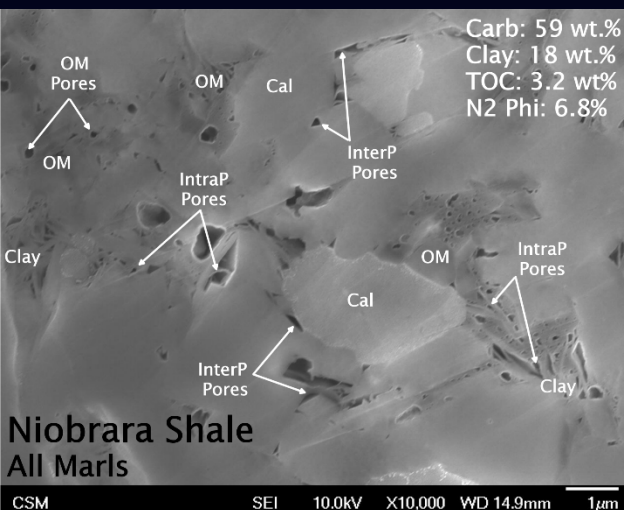
# N2 Pore Size Distribution vs. Clay Content



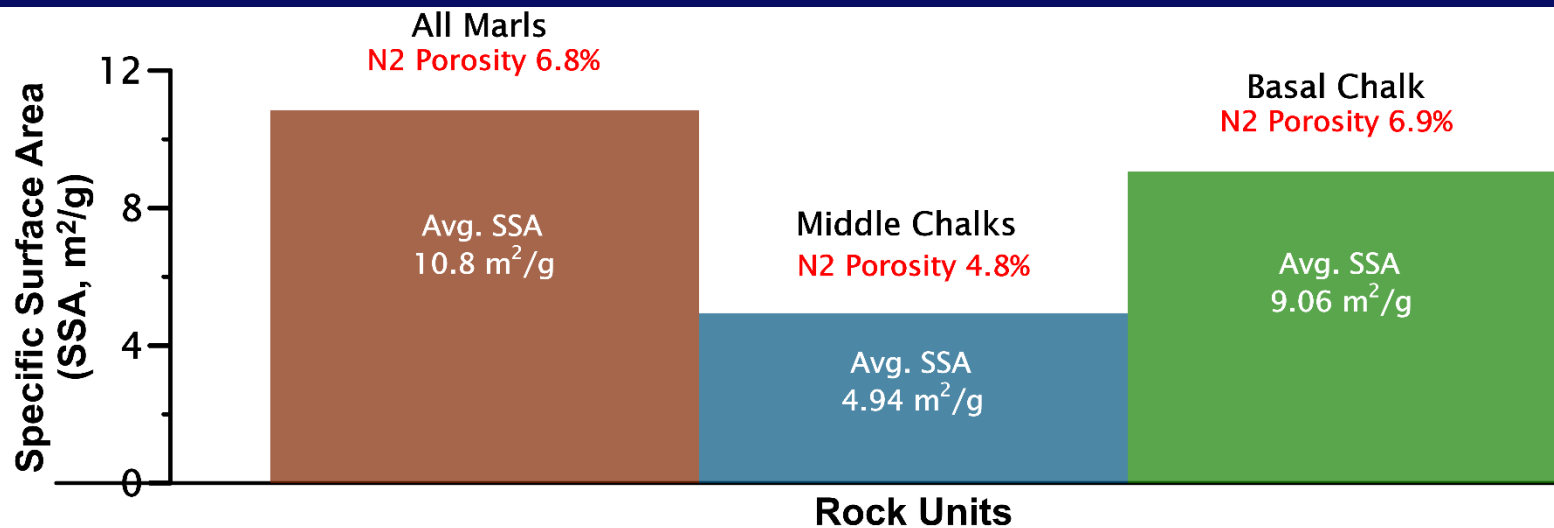
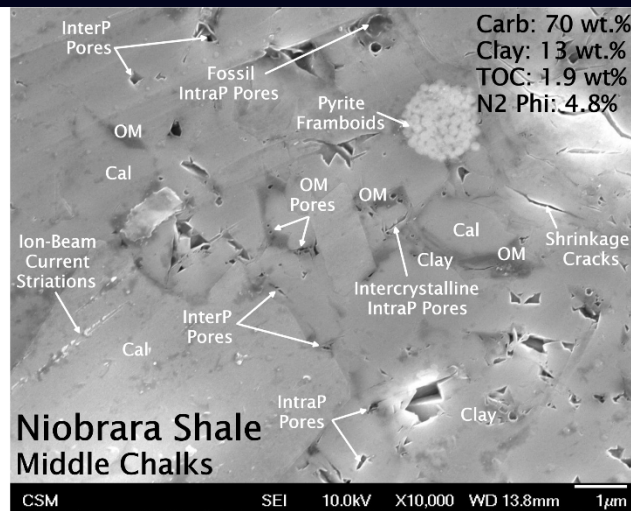
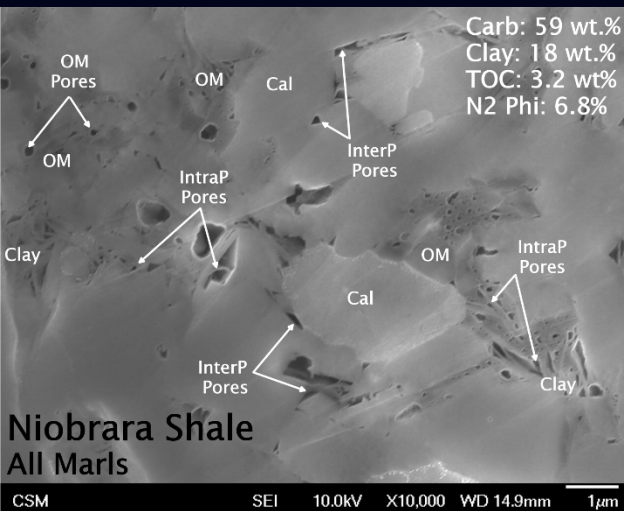
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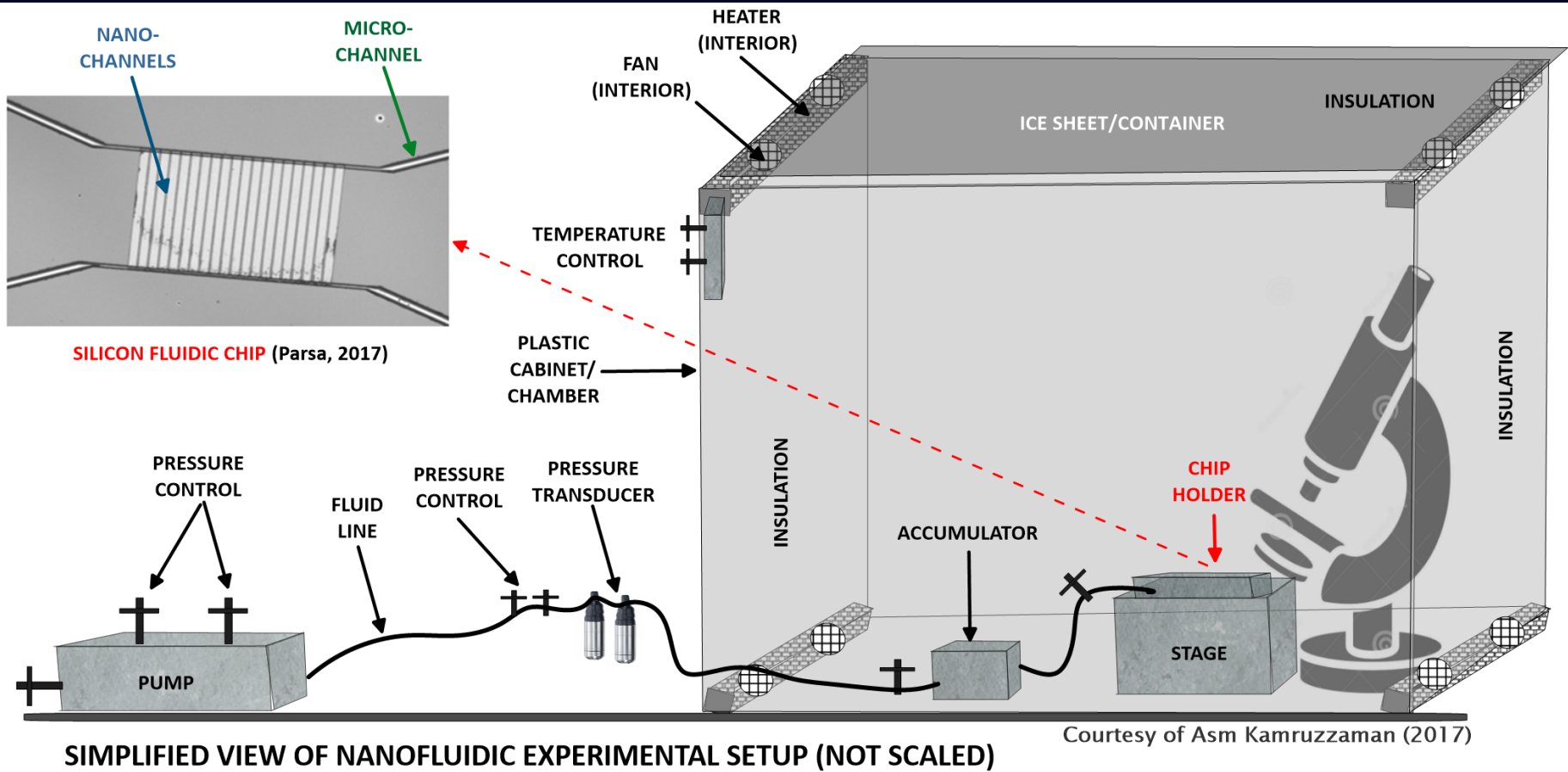
# N2 Pore Size Distribution vs. TOC Content



# N2 Porosity vs. Specific Surface Area (SSA)



# Laboratory Investigation of Nanoporous Flow





# Thank you

