SEDIMENTOLOGY, STRATIGRAPHIC VARIABILITY OF SHALE, AND CONTROLLING FACTORS AND PROCESSES

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Introduction

What is Shale?

- The most abundant sedimentary rock
- Fine-grained, composed of > 50% vol. mud (clay + silt)
- Forms in all depositional environments – lacustrine, fluvial, aeolian, deltaic, marine
- Classified based on texture, bedding, organic content, etc.

Chattanooga Shale, Tennessee
(https://mudstone.sitehost.iu.edu/field-photos-1.htm)

Introduction

Why is shale important?

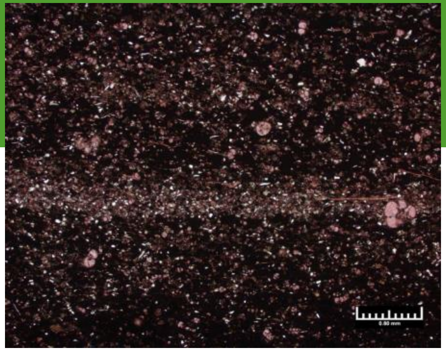
- Paleogeographic interpretation
- Hydrocarbon – conventional/unconventional
- CO_2 storage
- Green energy (shale gas?)
- Metalliferous ore deposits
- Many more…

Questions

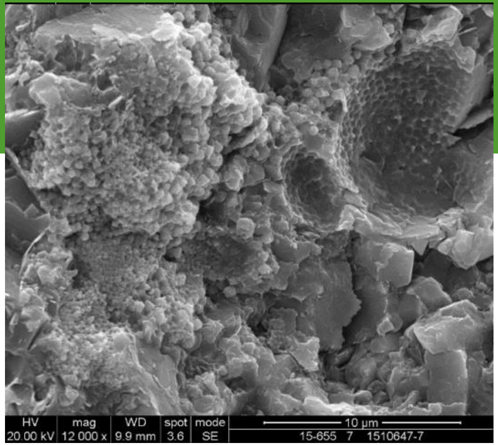
- ❑ What are shale, shale lithofacies, processes, environmental conditions?
- ❑ What effects do sedimentary processes have on stratigraphic completeness of shales?
- ❑ What controls variability/cyclicity of shale?
  - ❑ *Allogenic?*
  - ❑ *Autogenic?*

Objectives

- Understand the origin of shale
  - Processes associated with shale formation
  - degree of stratigraphic completeness and variability of shale
  - Distinguish allogenic from autogenic controls on shale deposition
  - Distinguish shales from different environments

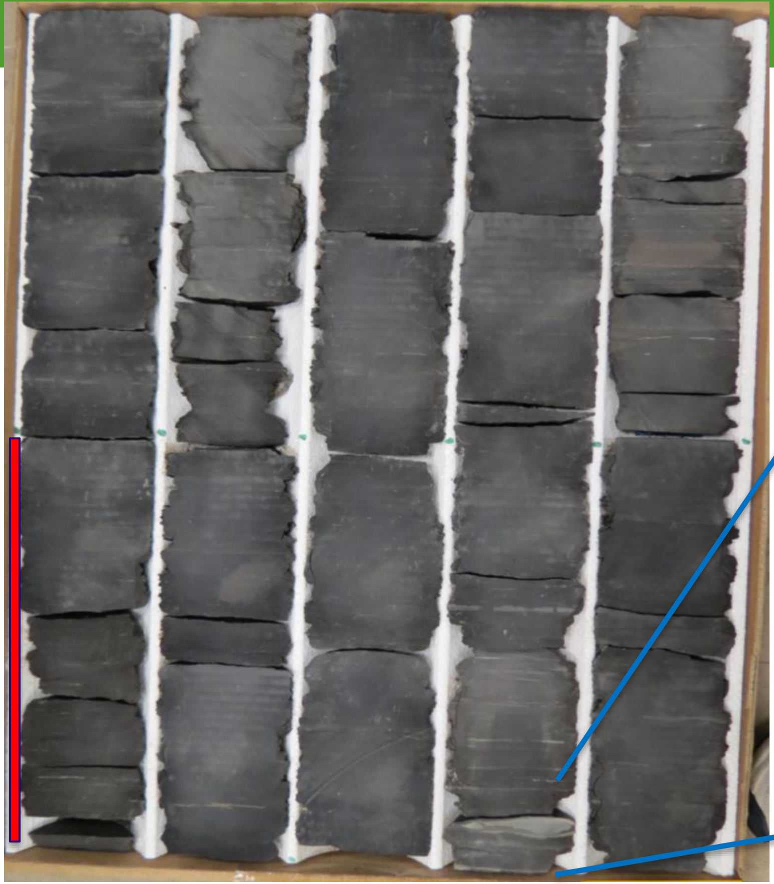


Thin section



SEM imaging

1 ft



core

Different scales of observation of shales. Core and thin section photos from Dr Wan Yang. SEM image from Lin *et al.* (2017)

Data and Methods

- Cores analysis
- Thin section analysis
- SEM analysis
- X-ray diffractometry

→ Mineralogy, texture, microstructure, boundary relations → Depositional processes of individual and sets of lamina

- Spectral analysis
- Gamma analysis

→ Orbital signals, sedimentation rates → Distinguish allogenic from autogenic controls

- Geochemical analysis
  - XRF/ICP-MS

→ Elemental and isotopic concentration → Depositional processes, source, water chemistry,

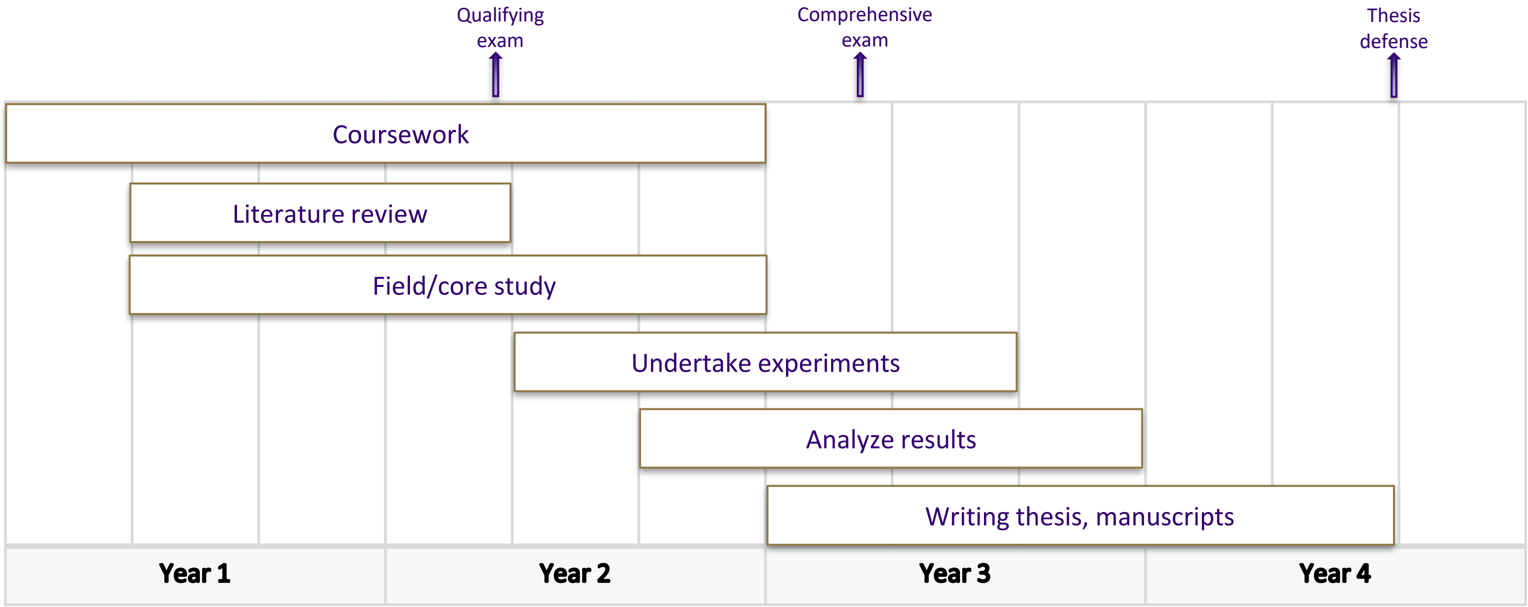
- Statistics
  - Principle component analysis?
  - Cluster analysis?

→ Shale classification

Expected Results

- An improved understanding of the processes controlling shale formation
- A new statistical-geochemical classification that provides details on shale origin
- Improved paleogeographic interpretation can be used to increase success rate of resource exploration

Tentative research plan



Tentative Budget

Analysis	Unit cost ($)	units	Total ($)
SEM	22	100 hours	2200
Thin section	40	100 samples	4000
Geochemical analysis	100	100 samples	10000
Grand total			16,200

Field Study:

gas, rental car, lodging, field gears, etc.

Acknowledgment

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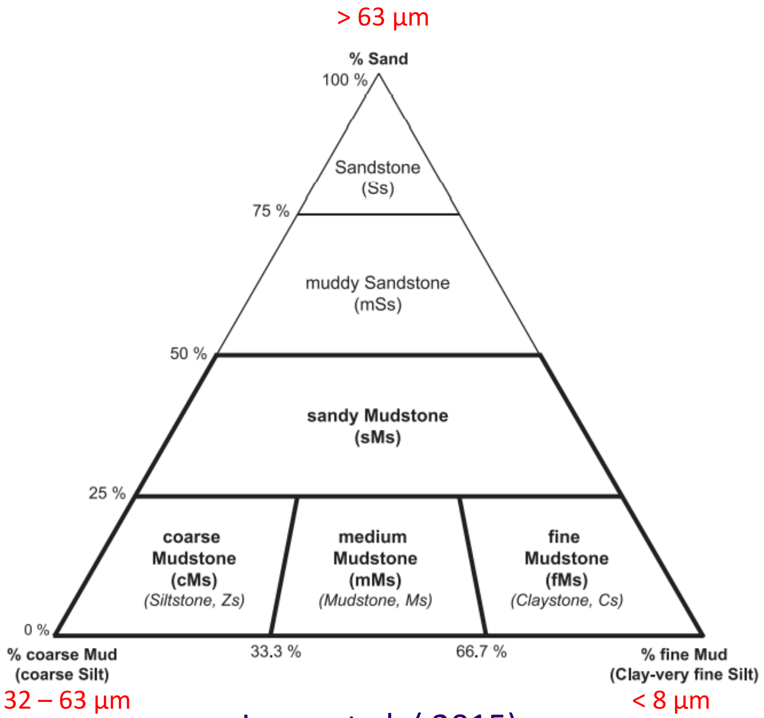
- Colleagues at McNutt Room 317



Lazar et al. (2015)

The shale oil resource in-place is massive, estimated at 1,315 billion barrels. However, only a small portion - - 6.5% of this resource (85 billion barrels) - - is technically recoverable with current practices.

Use of Shale EOR would add 48 billion barrels, providing space for storing 20 billion metric tons of CO_2.

Shale Basin/Formation	Resource In-Place (Billion Barrels)	Primary Recovery		Incremental Oil Recovery from CO_2 EOR (Billion Barrels)	Storage of CO_2 (Gmt)
		(Billion Barrels)	(%)*		
1. Williston Basin/Bakken Shale	90.8	10.0	11.1%	3.7	1.5
2. South Texas/Eagle Ford Shale	139.3	12.6	9.0%	7.6	1.8
3. Permian Basin					
• Midland Basin/Wolfcamp Shale	509.1	26.1	5.1%	14.2	6.5
• Delaware Basin/Wolfcamp Shale	575.7	36.2	6.3%	21.8	10.0
Total	**1,314.9**	**84.9**	**6.5%**	**47.5**	**19.9**

*Primary Recovery as a % of OOIP.

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Advanced Resources International, Inc.

The Next Phase Of The Shale Oil Revolution - Storing CO_2 With Shale EOR (US Energy Association)