

CCS Potential in Lyons Formation in Redtail Area, Denver Basin

Rashed Alzahrani

M.S Student , Spring 2025



COLORADO SCHOOL OF
MINES
MUDTOC



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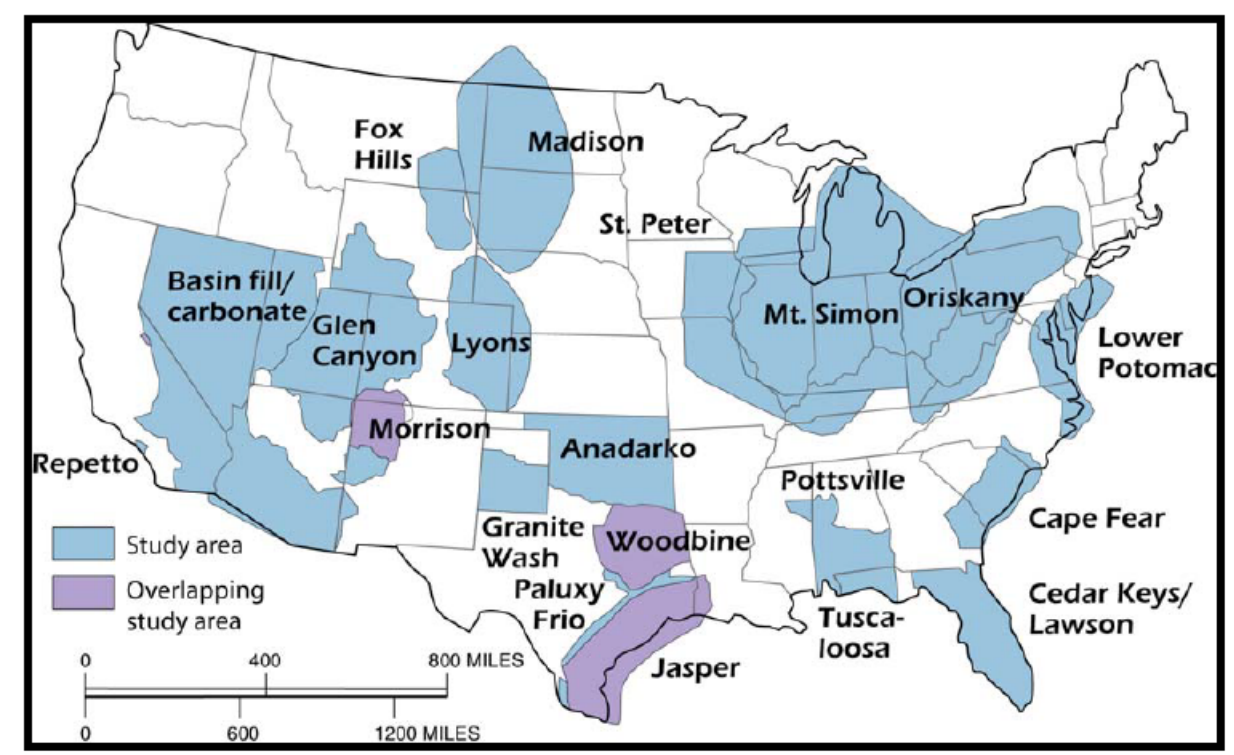
INTRODUCTION & MOTIVATION



Introduction

The Lyons Formation

- Subject of interest for hydrocarbon exploration since its discovery in the Keota Field, Weld County, Colorado in 1953 (Nering, 1963)
- Holds potential for studying large-scale sedimentary structures
- Recently recognized for its viability as a target for CO₂ storage in Colorado.
- *It is estimated to have the capability of storing approximately 500 million short tons of CO₂ (Young et al. in 2009).*

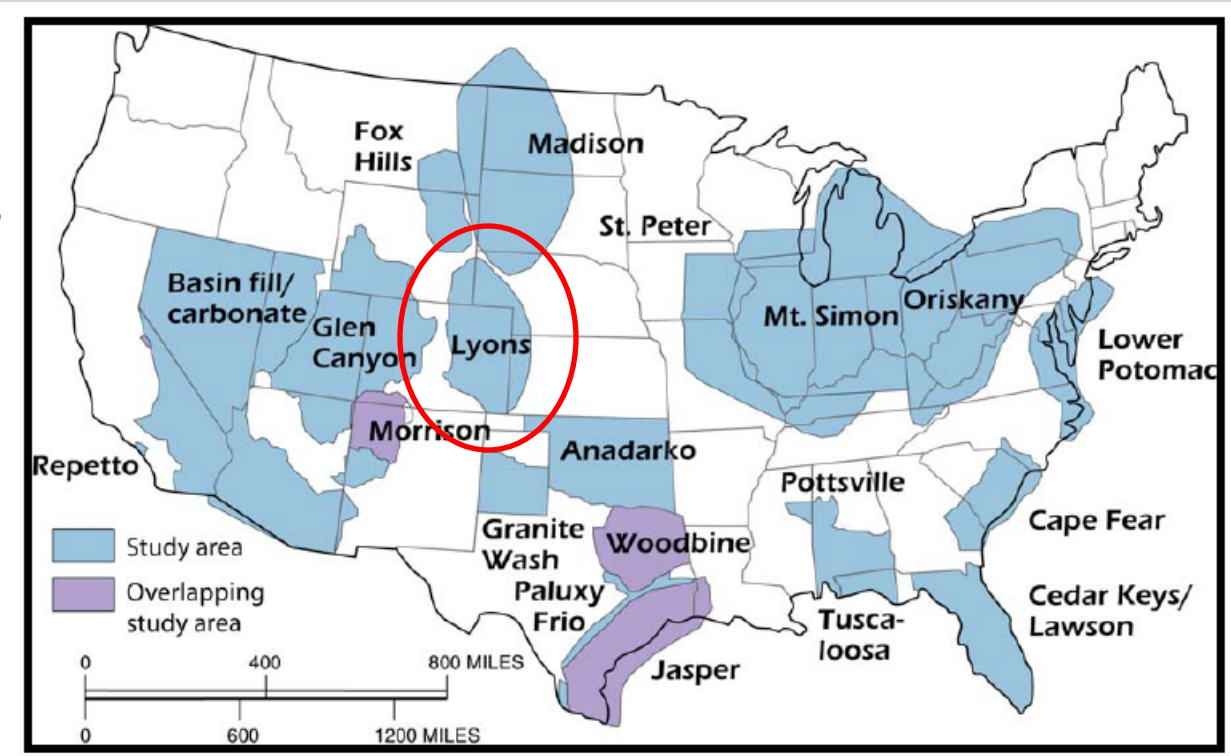


(Hovorka et al., 2000; Young, 2004)

Introduction

Criteria for Target Selection in CO₂ Sequestration:

- **Salinity:** Formations with salinity >1,000 ppm, ideally >10,000 ppm, to avoid water supply contamination
- **Absence of Water Supply Development:** Deep formations not currently or prospectively used as water sources
- **Depth:** 1,000-1,200 m for optimal density-pressure conditions
- **Porosity and Permeability:** Sandstone or oil/gas-producing formations with ≥ 1 Darcy permeability and ≥ 100 m thickness
- **Top Seal:** Impermeable geologic unit or structure to prevent vertical migration and aquifer contamination



(Hovorka et al., 2000; Young, 2004)



PROPOSED RESEARCH



PURPOSE AND OBJECTIVES

Purpose

Conduct a comprehensive geologic characterization of the Lyons Formation in the Red-tail Field, Denver Basin, with a focus on examining its carbon sequestration potential.

Objectives

- Lithologically define the Lyons Formation through core analyses and petrographic thin section studies.
- Establish a stratigraphic framework for the Lyons Formation using core interpretations, field analogs, thin section studies, and well logs.
- Evaluate the carbon sequestration potential of the reservoir by petrophysically interpreting the core test data and dataset analyses.
- Conduct an outcrop analog study to examine the lateral and vertical variations, as well as the facies associations, of the Lyons Formation.
- Define the extent and characteristics of the Lyons Formation that make it a suitable target for carbon sequestration and identify potential well locations for CO₂ injection.

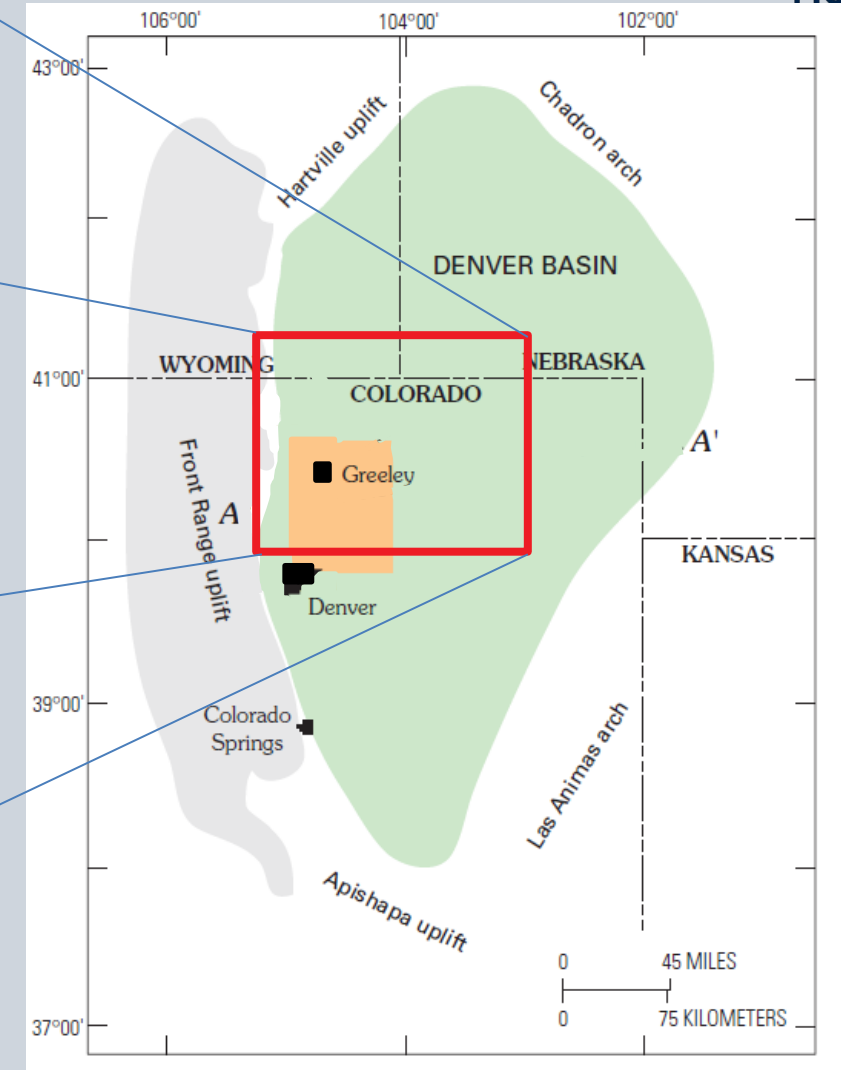
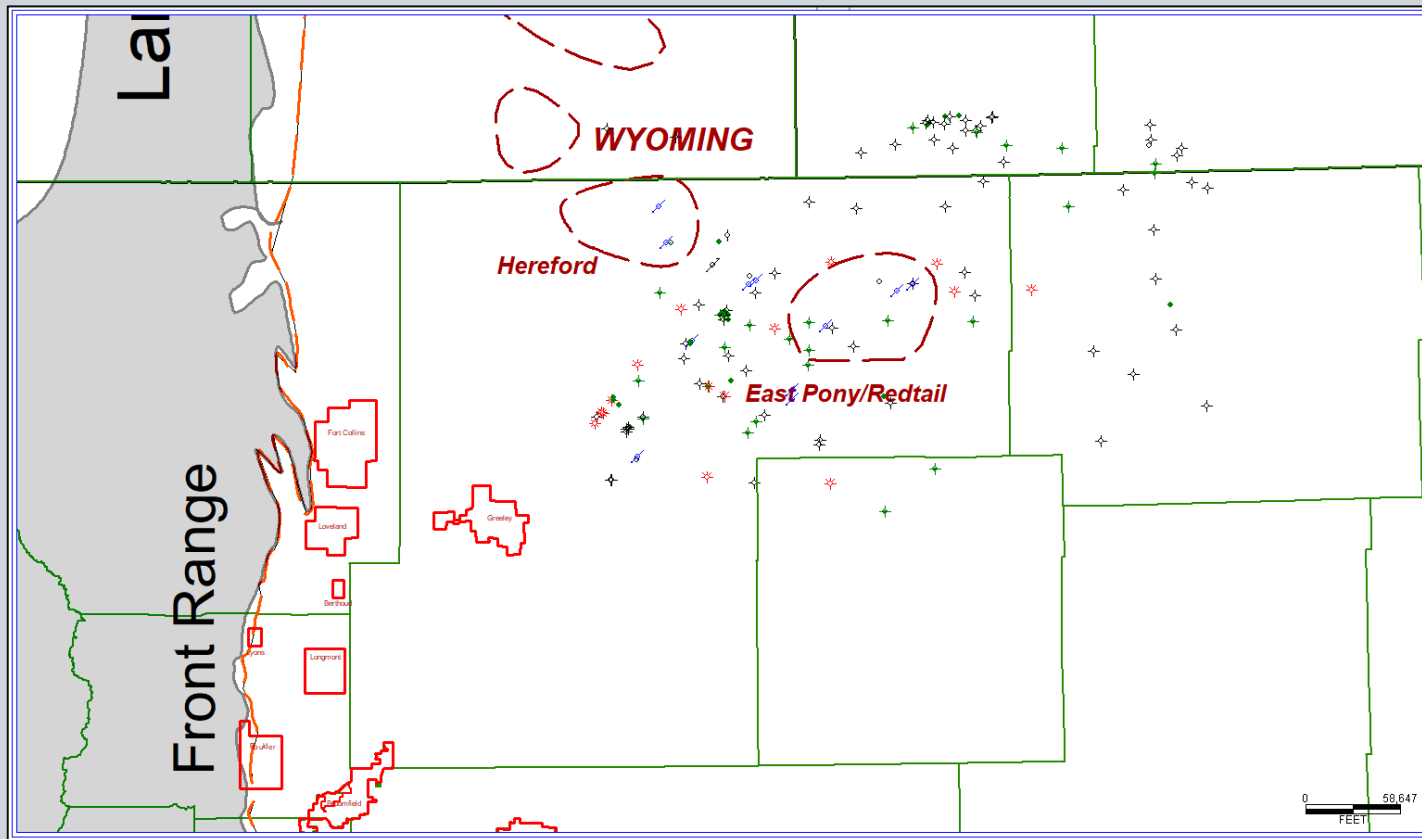
Significance

The study aims to contribute to future projects aimed at secure CO₂ storage within Colorado by expanding the geological understanding of the Lyons in the region.



STUDY AREA & DATA SET

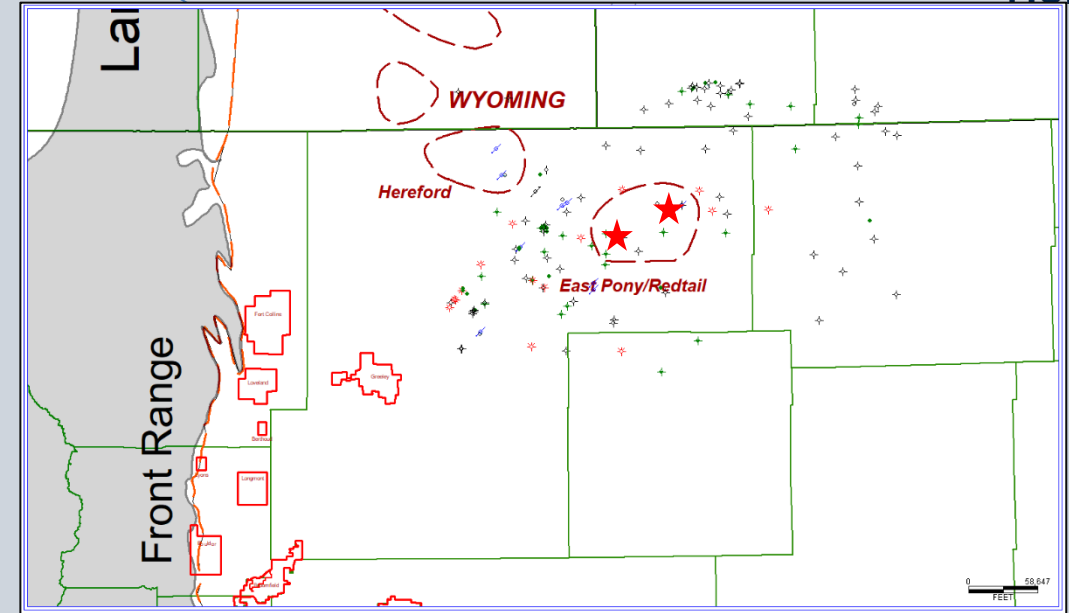
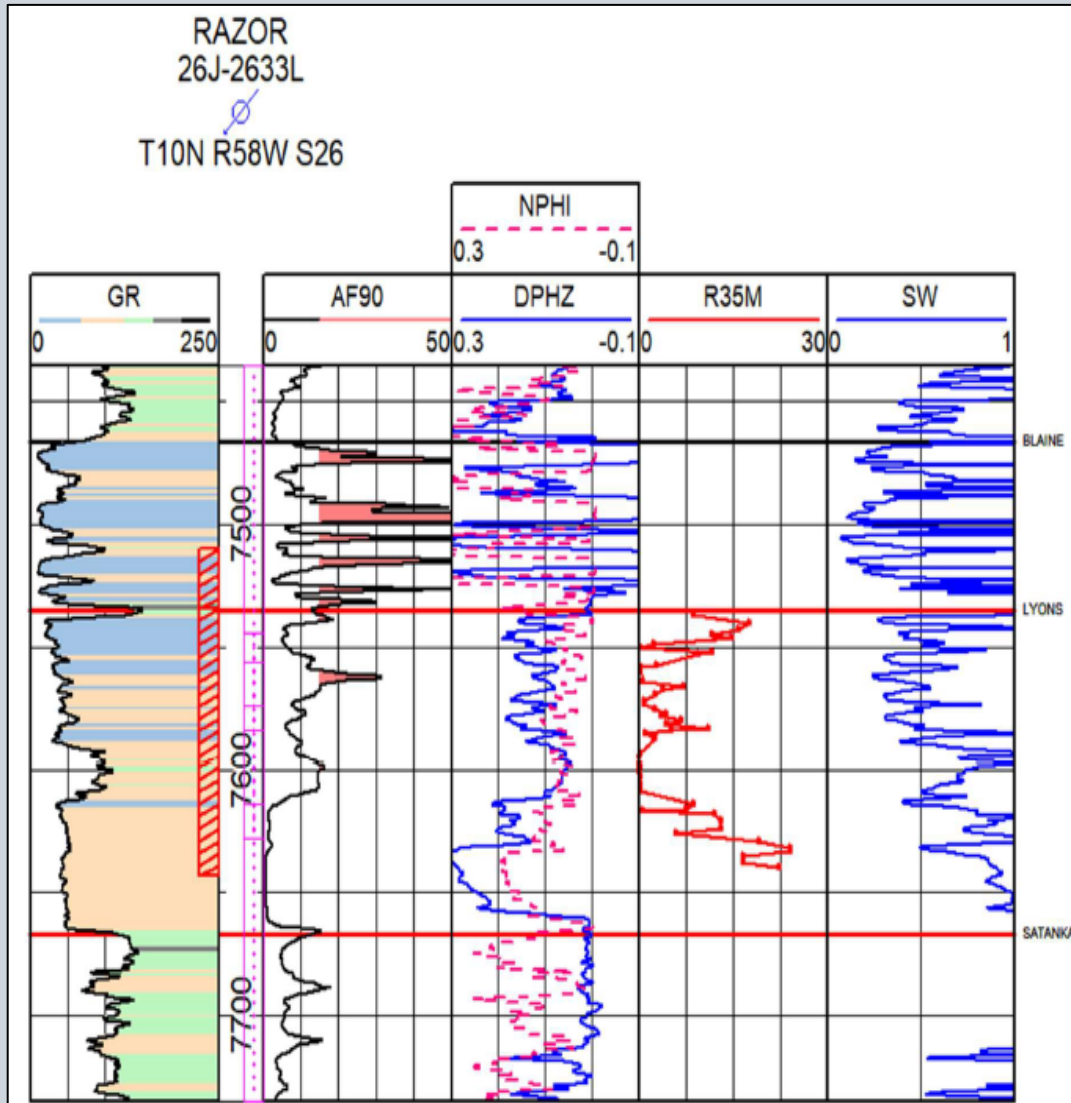
STUDY AREA & DATA SET



- +200 Wells with Lyons penetration
- +40 wells with Lyons core in Colorado
- 2 nearby wells with Lyons core within Redtail Field area

(Modified after Matuszczak, 1973)

STUDY AREA & DATA SET



Well	Well Name in Study	Operator	Core length (# cores)
051233749500	Razor 26J – 2633L	Whiting Oil & Gas	107 ft
051233737400	Wildhorse 16	BNN Western LLC	110 ft
05123348900	Ball Ranch AC15-04	Noble Energy	114 ft

Methodology

Detailed Core Descriptions:

- Identify facies and lithologies and interpretation.

Petrographic Analysis:

- Select representative samples based on core descriptions
- Characterize facies at a smaller scale
- Assess parameters like permeability and porosity

Comparative Analysis:

- Compare petrographic observations across different wells
- Understand the heterogeneity within the Lyons sandstone facies

Mapping and Correlations:

- Use Petra software to map isopach (thickness) and structure of key horizons
- Correlate wireline logs and lithologies across the study area
- Identify depositional trends and structural framework

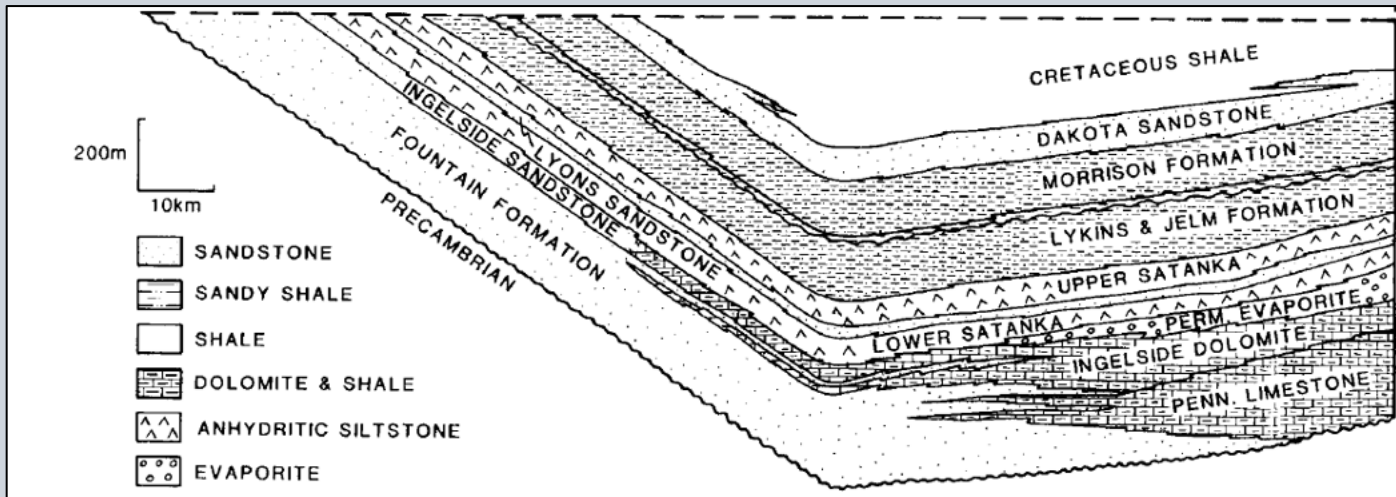


GEOLOGIC SETTING

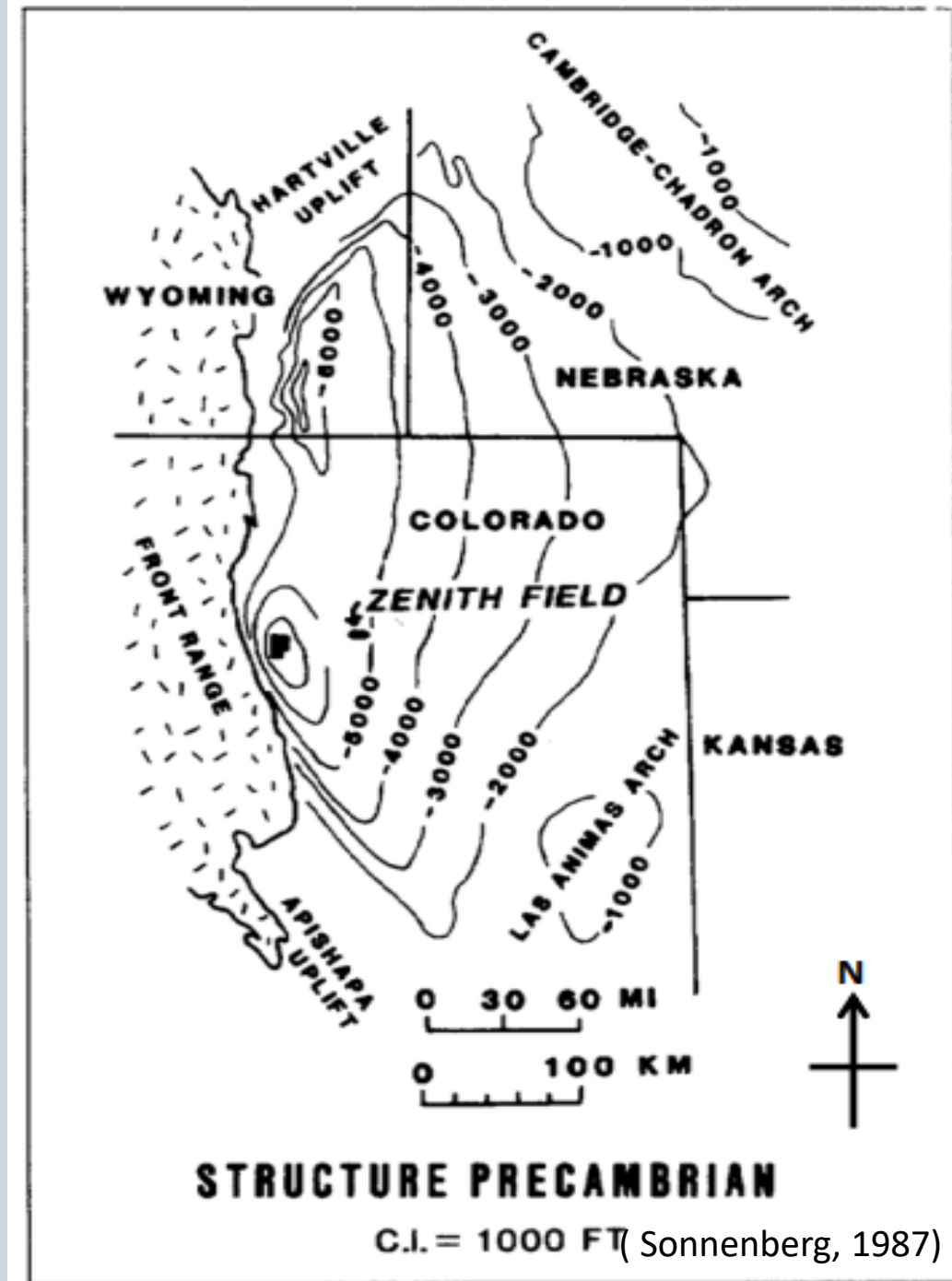


Geological Setting

- The Denver Basin experienced tectonic adjustments, including orogenic and epeirogenic processes.
- It is part of a retro-arc foreland basin in eastern Colorado, western Kansas, western Nebraska, and southeastern Wyoming.
- The basin has an asymmetrical shape with a steep western side and a gentler eastern slope.
- The deepest section of the basin reaches a depth of 13,000 ft along the Front and Laramide Ranges.



(modified after Lee and Bethke, 1994)



Geological Setting

Sedimentary Succession:

- Sedimentary rocks ranging from Cambrian to Recent, except for Silurian system (Garbarin & Veal, 1968)

Pennsylvanian Period:

- Ancestral Rocky Mountains uplifted, depositing coarse arkosic clastic sediments
- Fountain Formation is the initial formation associated with this period

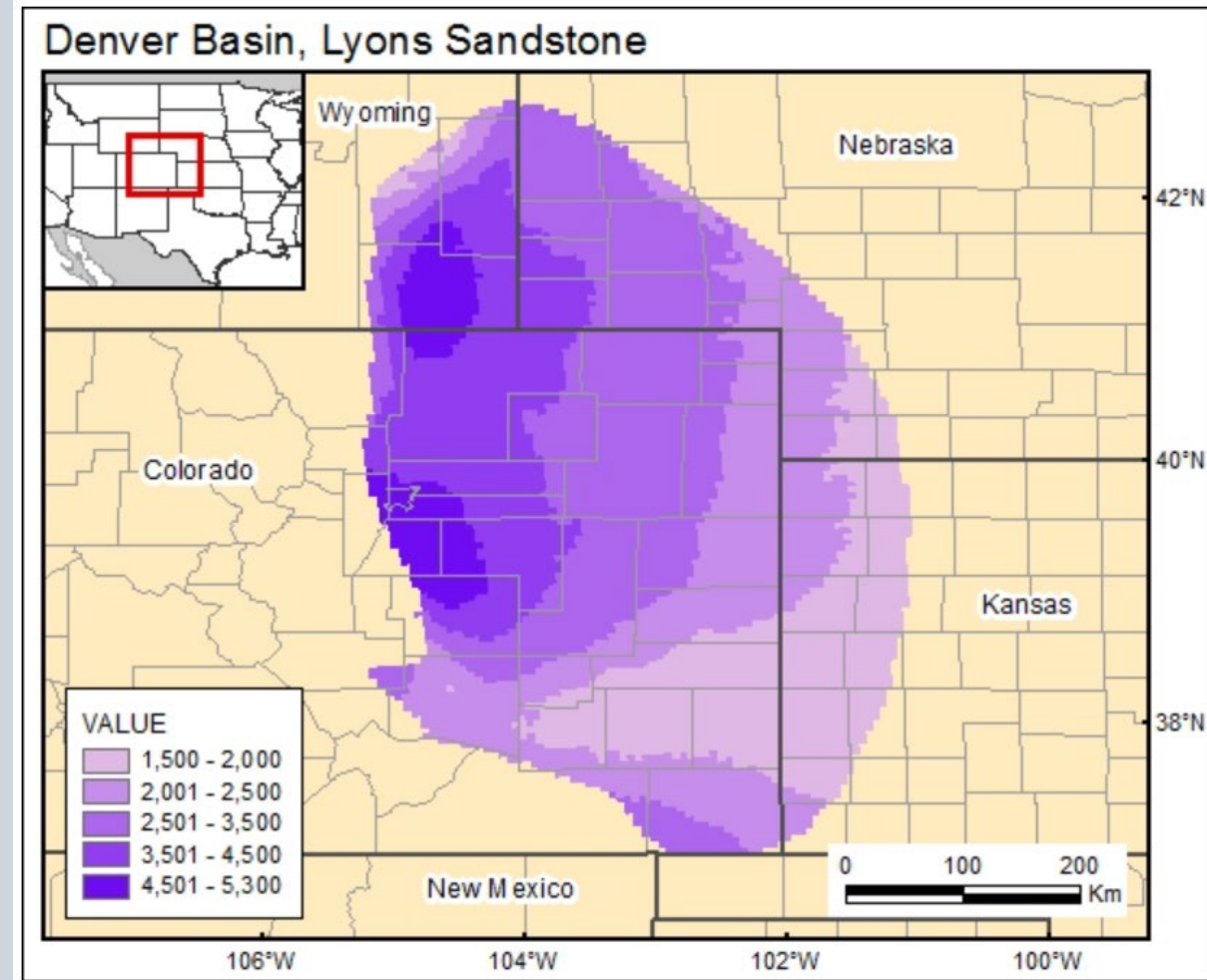
Permian Period:

- Continued uplift of Ancestral Rockies, resulting in thick deposits of coarse material
- Permian deposits include:**
 - Upper Fountain Formation
 - Ingleside Formation
 - Owl Canyon Formation
 - Lyons Sandstone
 - Lower Lykins Formation

NORTHERN FRONT RANGE, OUTCROP			ADJACENT DENVER BASIN	
LOWER CRETACEOUS	Dakota Group	South	North	Muddy ("J") Sandstone
		Upper members, South Platte Formation	Muddy ("J") Sandstone	
		Plainview Ss. Member	Skull Creek Shale	Skull Creek Shale
		Lytle Formation	Plainview Formation	"Dakota" of drillers
		Lytle Formation		"Lakota" of drillers
JURASSIC		Morrison Formation		Morrison Formation
		Ralston Creek Formation		Older Jurassic rocks may be present
		Sundance Formation		
TRI.		Jelm Formation		Jelm Formation
PERMIAN		Lykins Formation		Lykins Formation
		Lyons Sandstone		Lyons Sandstone
		Owl Canyon Formation		Owl Canyon Formation
		Ingleside Formation		Ingleside Formation
PENNSYLVANIAN		Fountain Formation		Fountain Formation
MISS.				Mississippian rocks
DEV.				Devonian rocks
SIL.				Ordovician rocks
ORD.				Ordovician rocks
CAM.				Cambrian rocks
PRE-CAM.				Metamorphic and intrusive rocks

Lyons Formation

- Primarily consists of Permian-age (Leonardian Stage) Sandstone.
- Exposed along the western margin of the Denver Basin, along the Front Range of the Rocky Mountains
- Thickness:
Generally uniform thickness of 40 to 50 feet
Localized areas can exhibit greater thickness, up to 200 feet
- Depth at Redtail ranges around 7550 feet.

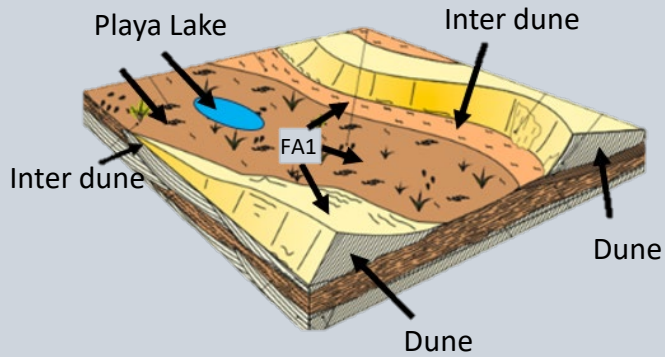


(Modified after Garbarini, G., and Veal, H. K., 1968)

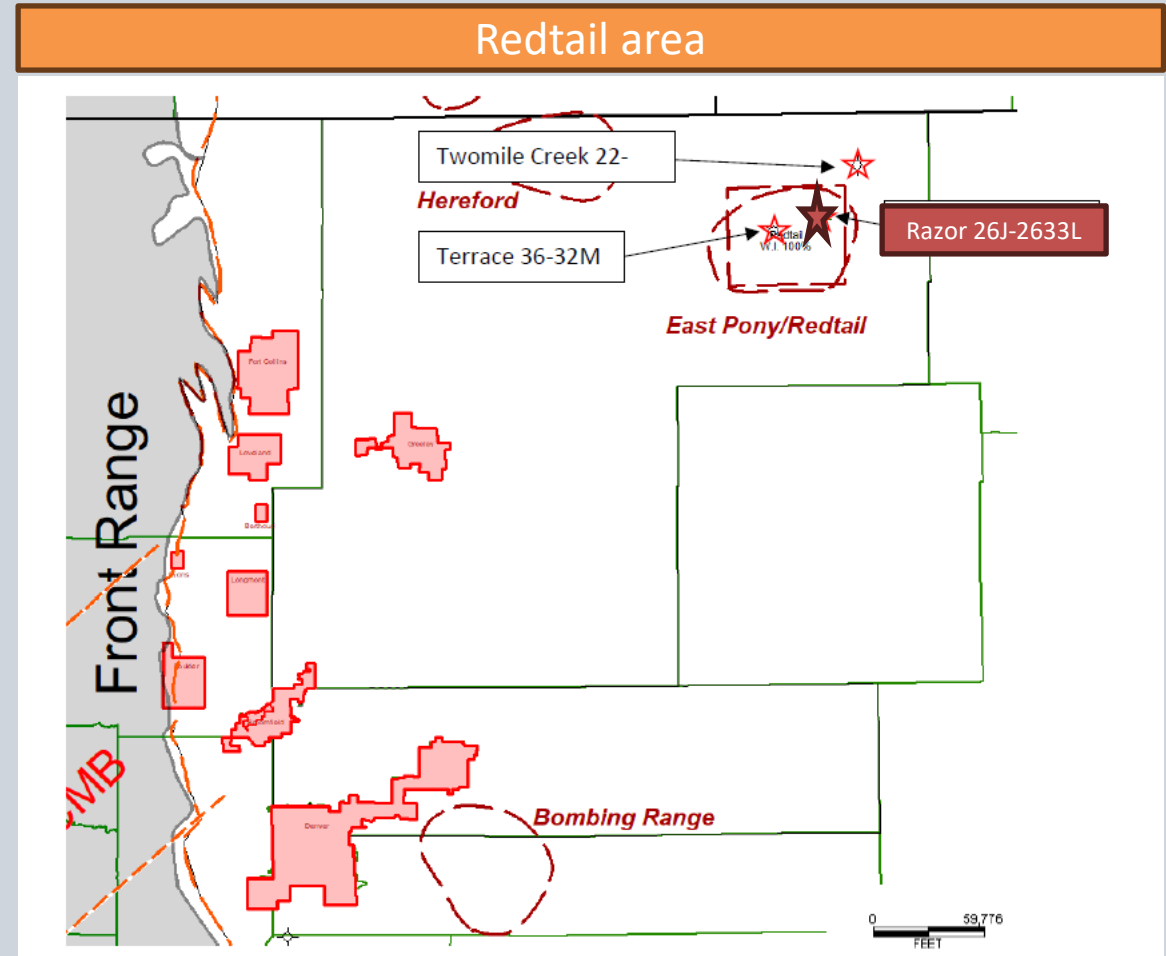
Source: gcc.beg.utexas.edu

Lyons Formation

Lyons core interpretation, Redtail area, Denver basin.



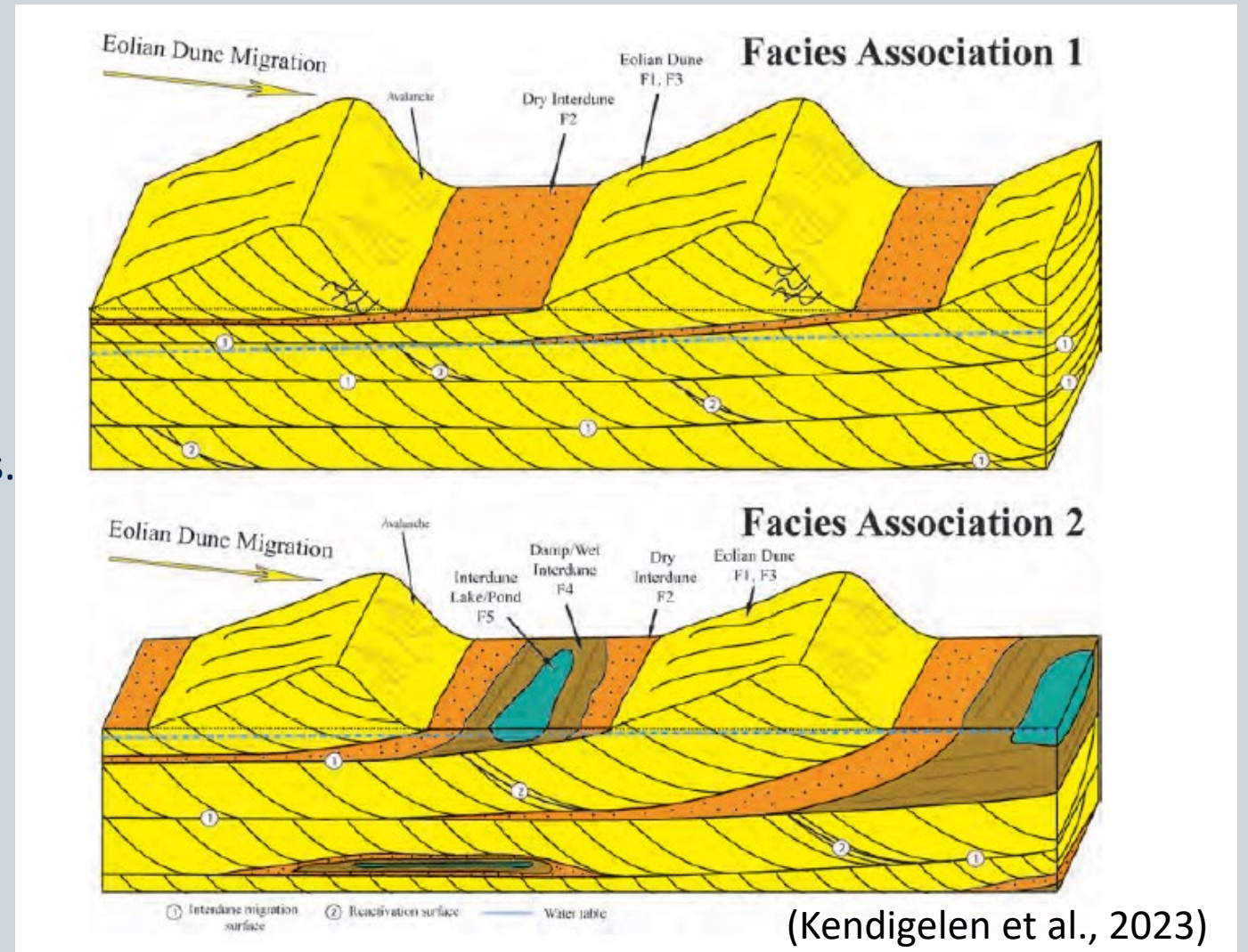
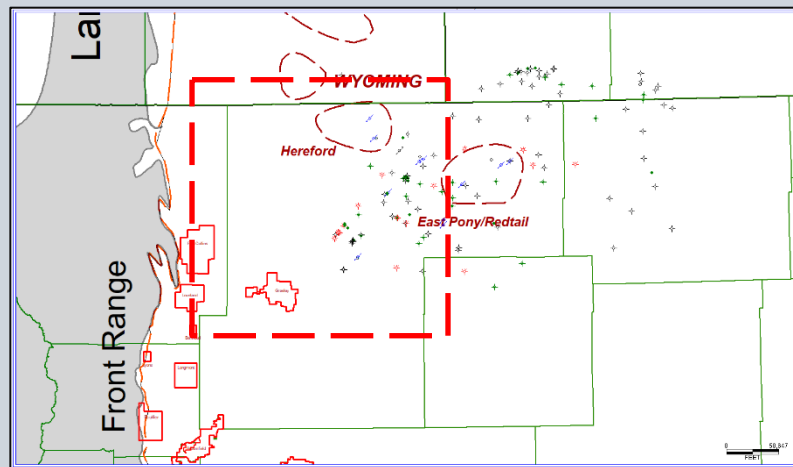
- F1** Low angle wind ripple-laminated sandstone
- F2** High angle grainflow-laminated sandstone
- F3** Massive to weakly cross-bedded sandstone
- F4** Horizontal planar-laminated sandstone
- F5** Soft sediment-deformed sandstone
- F6** Wavy-laminated sandstone
- F7** Massive siltstone



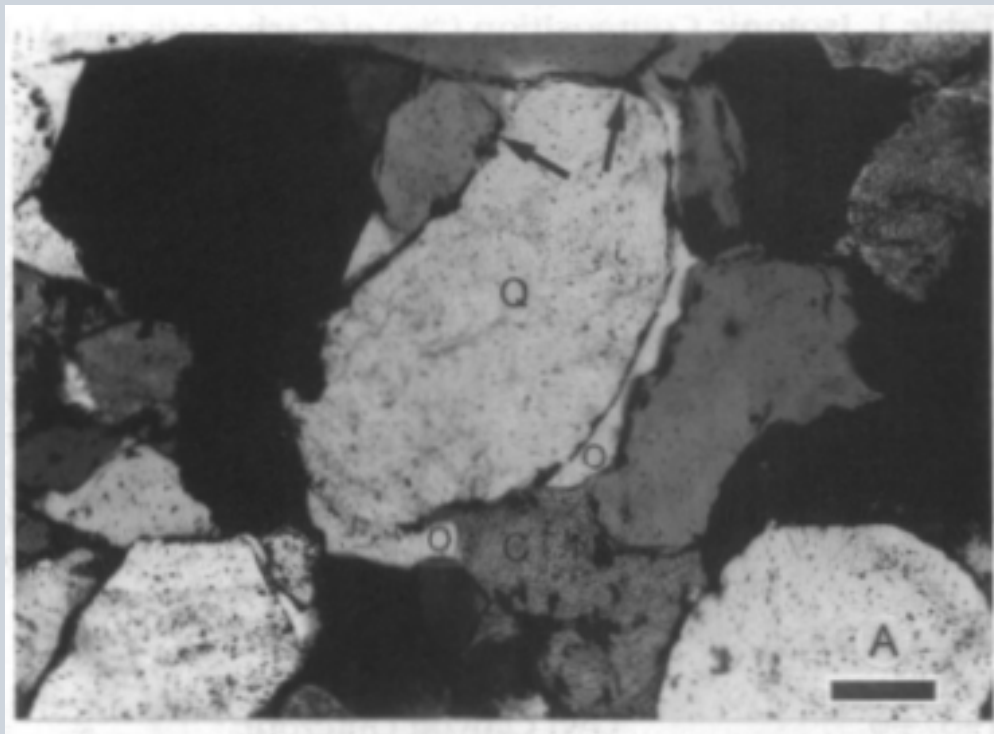
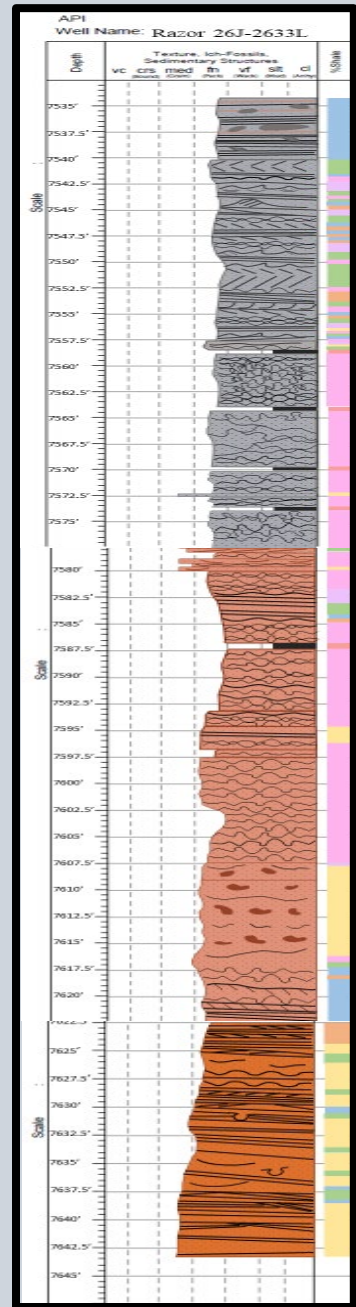
Lyons Formation

Kendigelen et al., 2023, identified five siliciclastic facies within the Lyons sandstone:

- (Facies Association 1): Eolian dune remnants, interdune deposits, lower dune flanks.
- (Facies Association 2): Wet to damp interdune deposits, ponded water areas.

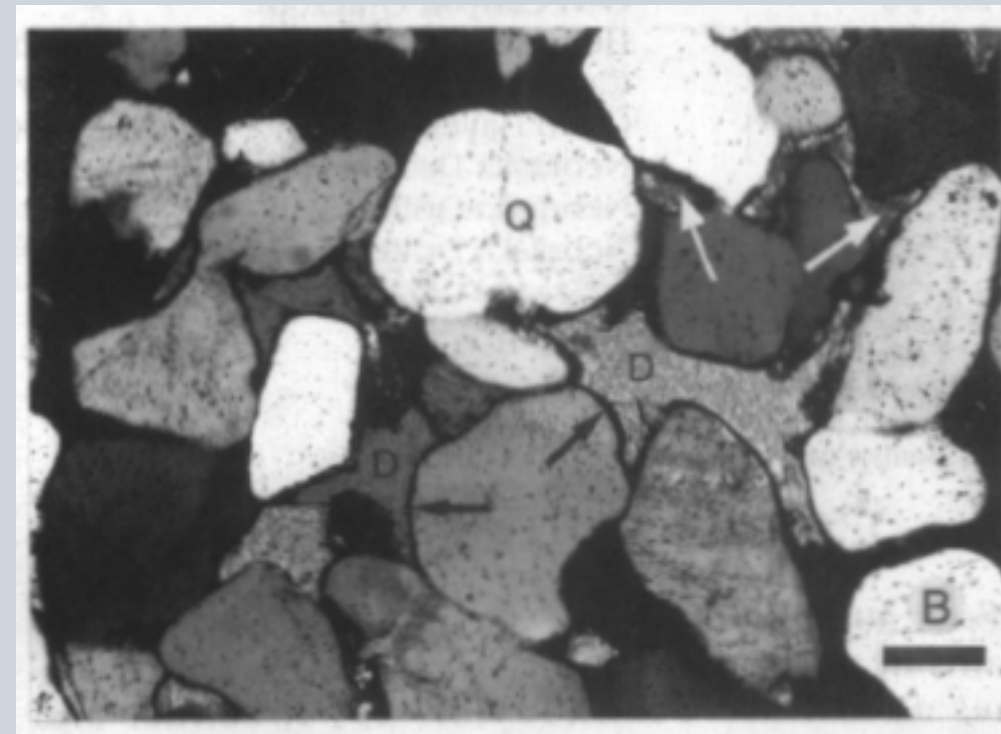


Previous Studies



Red Facies of Lyons Sandstone:

- Hematite coats the original surfaces of quartz grains (Q) overgrowths of secondary quartz (O)
- Calcite cement (C) fills some pore spaces.



Gray Facies of Lyons Sandstone:

- Dolomite (D) and anhydrite cements fill pore spaces
- Organic matter coats quartz grains (Q) and overgrowths



PROJECT TIMELINE



Project timeline



	2024					2025						
Thesis Timeline	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Course Work	█	█	█	█	█							
Research	█	█	█	█	█	█	█	█	█			
Write Proposal	█											
Gather Data		█	█									
Preliminary Interpretation		█	█									
Core Descriptions			█									
Thin Section Analysis				█								
Construct Mapping/ Petrophysical Model				█								
Gather Data				█	█							
Final Interpretation					█	█						
CCUS Feasibility/ Volumetric						█						
Write Thesis						█	█	█	█			
Defend Thesis									█			
Graduate										█		

Research Funding and Budget

The tuition and fees for the Master of Science program in Geology at the Department of Geology and Geological Engineering at Colorado School of Mines is sponsored by Saudi Aramco. All the necessary data, software and technology required for data analysis for the study are provided through Colorado School of Mines.

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THANK YOU





COURSEWORKS



Coursework

Semester	Course Number	Course Title	Credits	Grade
Fall 2023	GEOL 501	Applied Stratigraphy	4	A
Fall 2023	GEOL 613	Geologic Reservoir Characterization	3	A
Fall 2023	GEOL 557	Earth Resources Data Science: Fundamentals	3	A
Spring 2024	GEOL 551	Applied Petroleum Geology	3	*
Spring 2024	GEOL 552	Unconventional Petroleum Systems	3	*
Spring 2024	EBGN 502	Political Economy of Energy Transition	3	*
Fall 2024	CCUS 520	Geological Carbon Capture Utilization and Sequestration (CCUS)	3	***
Fall 2024	CCUS 521	Climate Change and Sustainability	3	***
Fall 2024	GEOL-701	Thesis	-	***
Spring 2025	GEOL-701	Thesis	-	***
Total Class Credits			25	
Total Research Credits			12	

Courses information table. (*) Currently enrolled. () Planned course***

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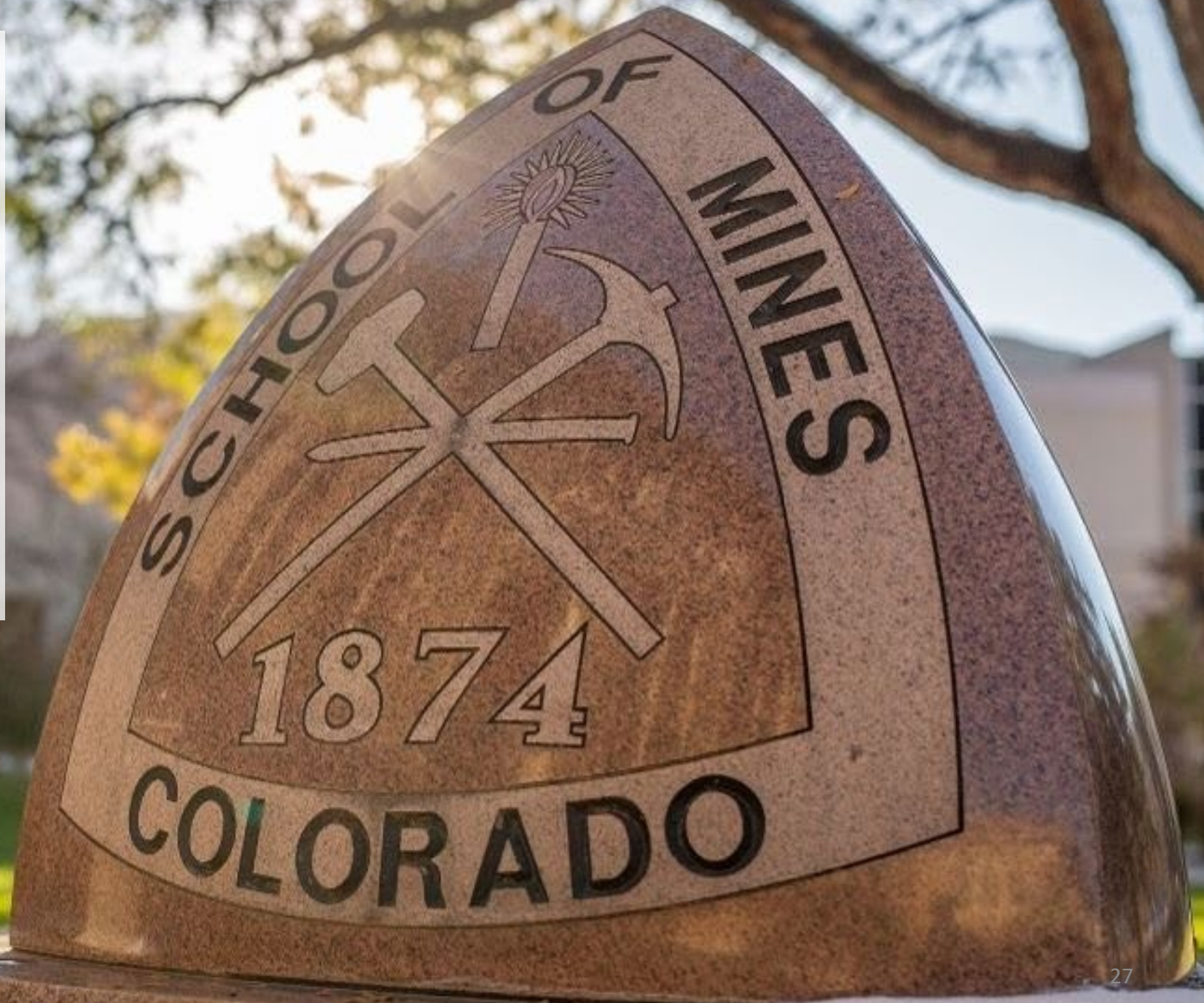


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Study objectives

Minor Questions

- What is the geology of the formation?
- What are the reservoir properties?
- Are there any natural traps or seals present in the formation that can prevent CO2 leakage?

