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Critical Challenges. Practical Solutions.

Energy & Environmental Research Center (EERC)

Williston Basin Associated CO_2 Storage Field Laboratory

DE-FE 0031694

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Partners

U.S. DEPARTMENT OF ENERGY

NATIONAL ENERGY TECHNOLOGY LABORATORY

slb

ExxonMobil

Project Goal and Objective

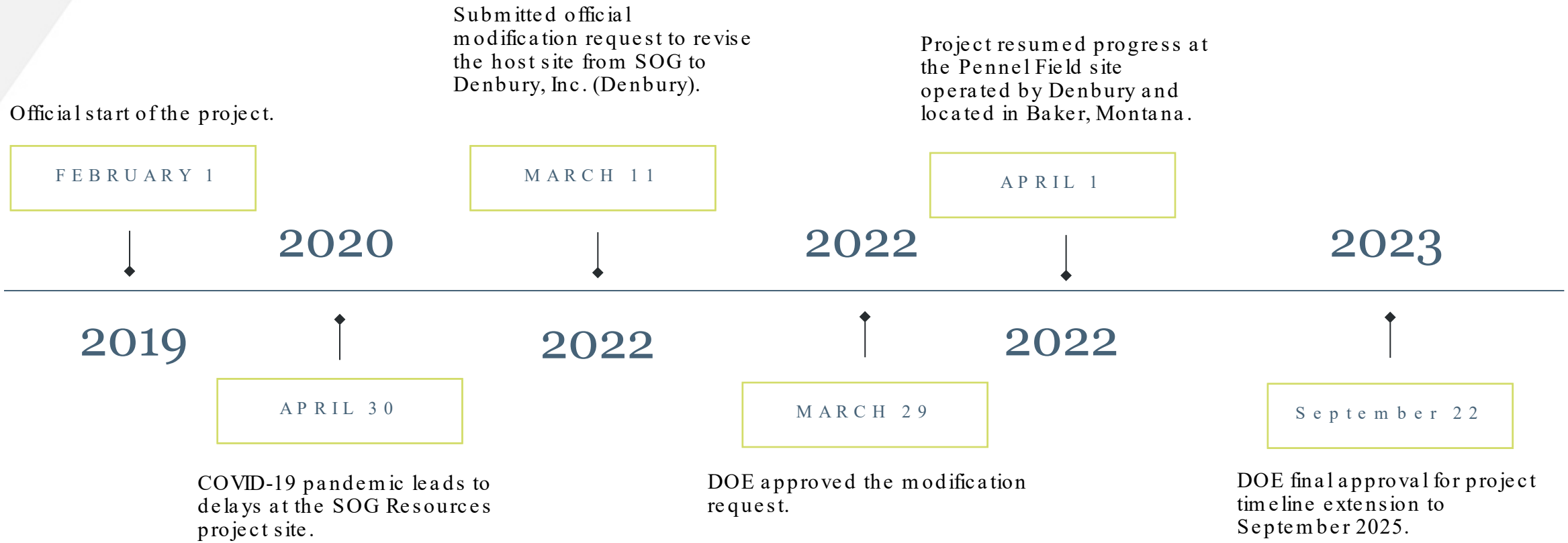
Goal: To advance associated geologic storage of CO_2 in the Williston Basin by establishing the Williston Basin Associated CO_2 Storage Field Laboratory (WBCFL)

- Generate field-based data on CO_2 enhanced oil recovery (EOR) with associated storage in stacked reservoirs.
- Characterize a residual oil zone (ROZ) for EOR and associated storage.
- Evaluate a monitoring, verification, and accounting (MVA) technique for its applicability to stacked CO_2 storage complexes.

Task/Subtask Breakdown

- **Task 1 – Project Management, Planning, and Reporting**
  - Subtask 1.1 – Project Management and Planning
  - Subtask 1.2 – Project Reporting and Technology Transfer
- **Task 2 – Fluid Behavior Studies**
  - Subtask 2.1 – Sample Collection and Compositional Analysis
  - Subtask 2.2 – MMP Studies
  - Subtask 2.3 – EOS and PVT Studies
- **Task 3 – Field Site Reservoir Characterization**
  - Subtask 3.1 – Core Sample Identification and Collection
  - Subtask 3.2 – Laboratory Determination of Petrophysical Properties
  - Subtask 3.3 – Field Monitoring of Reservoirs
  - Subtask 3.4 – Static Geomodelling
  - Subtask 3.5 – Dynamic Modeling
- **Task 4 – Active Seismoelectric Technology Demonstration**
  - Subtask 4.1– Active Seismoelectric Survey
  - Subtask 4.2 – Follow-Up Active Seismoelectric Survey
- **Task 5 – Life Cycle Analysis**
  - Subtask 5.1 – Life Cycle Analysis of the Field Test
  - Subtask 5.2 – Life Cycle Analysis of Stacked Storage

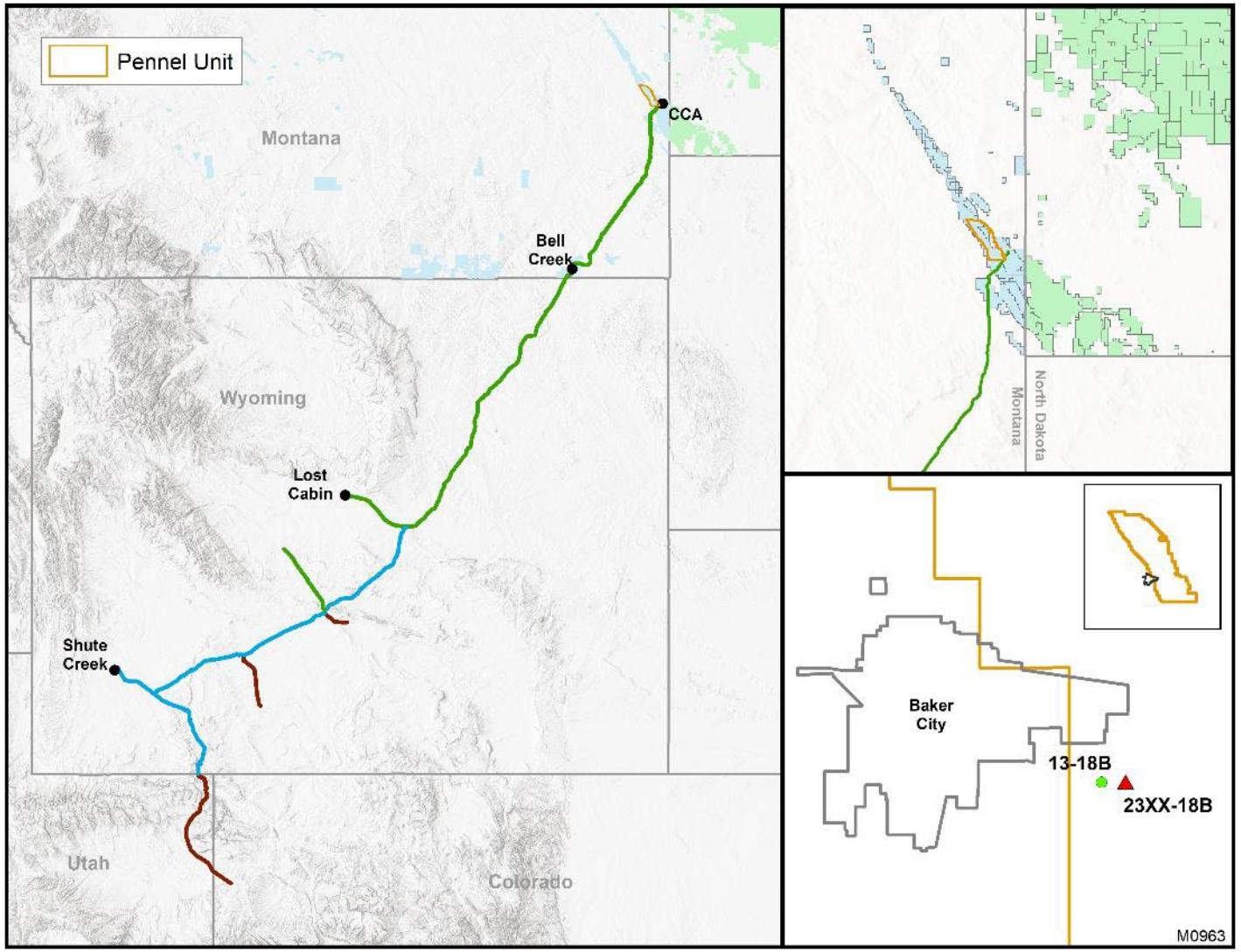
Project Management, Planning, and Reporting



The recent acquisition of Denbury by Exxon Mobil Corporation has further impacted the fieldwork and future operations schedule.

Project Location/CO_2 Source

- Near Baker, Montana
- Cedar Creek Anticline
- CO_2 sourced from Shute Creek and Lost Cabin gas plants (Wyoming)

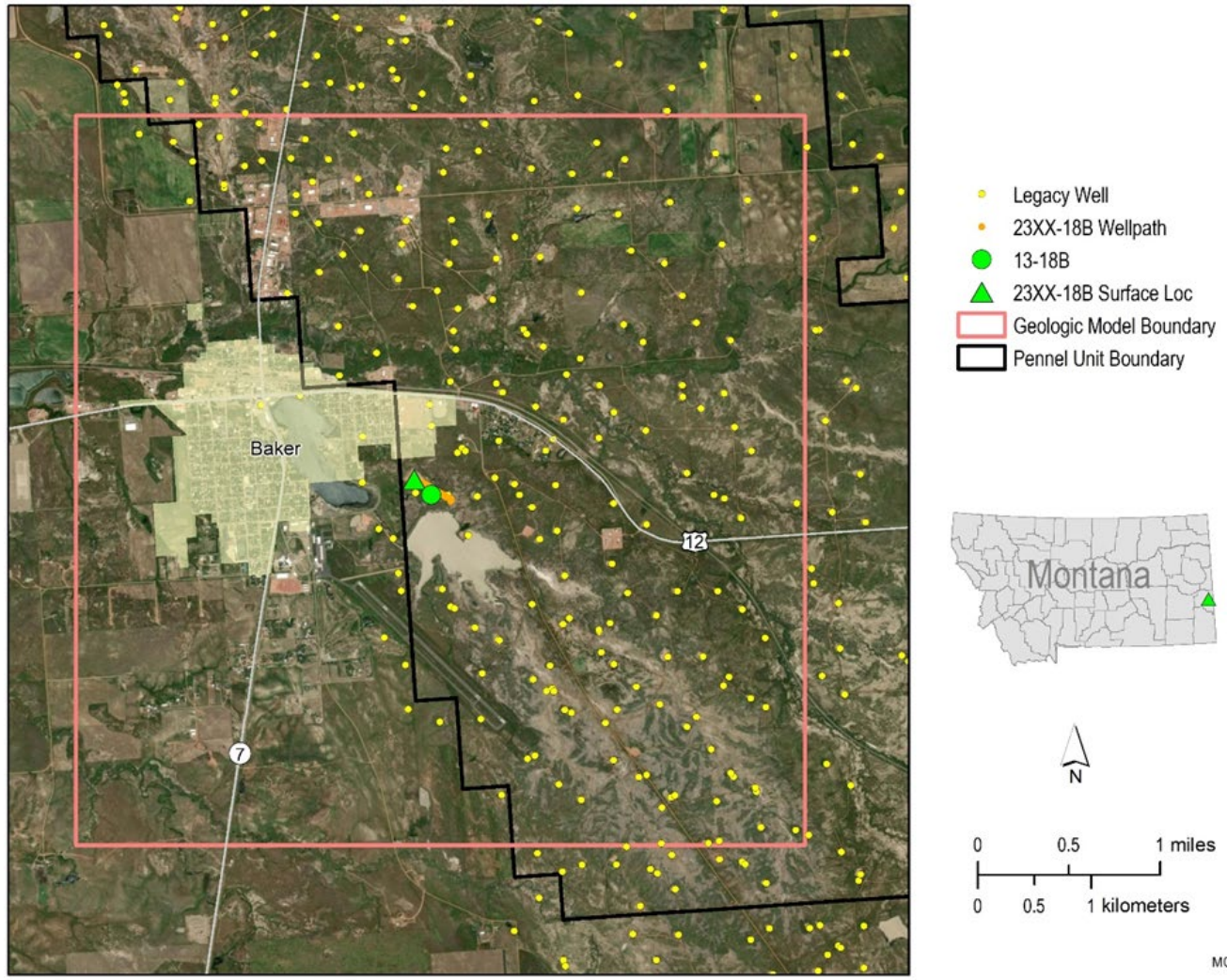


Study Area

Two wells will be used for the project:

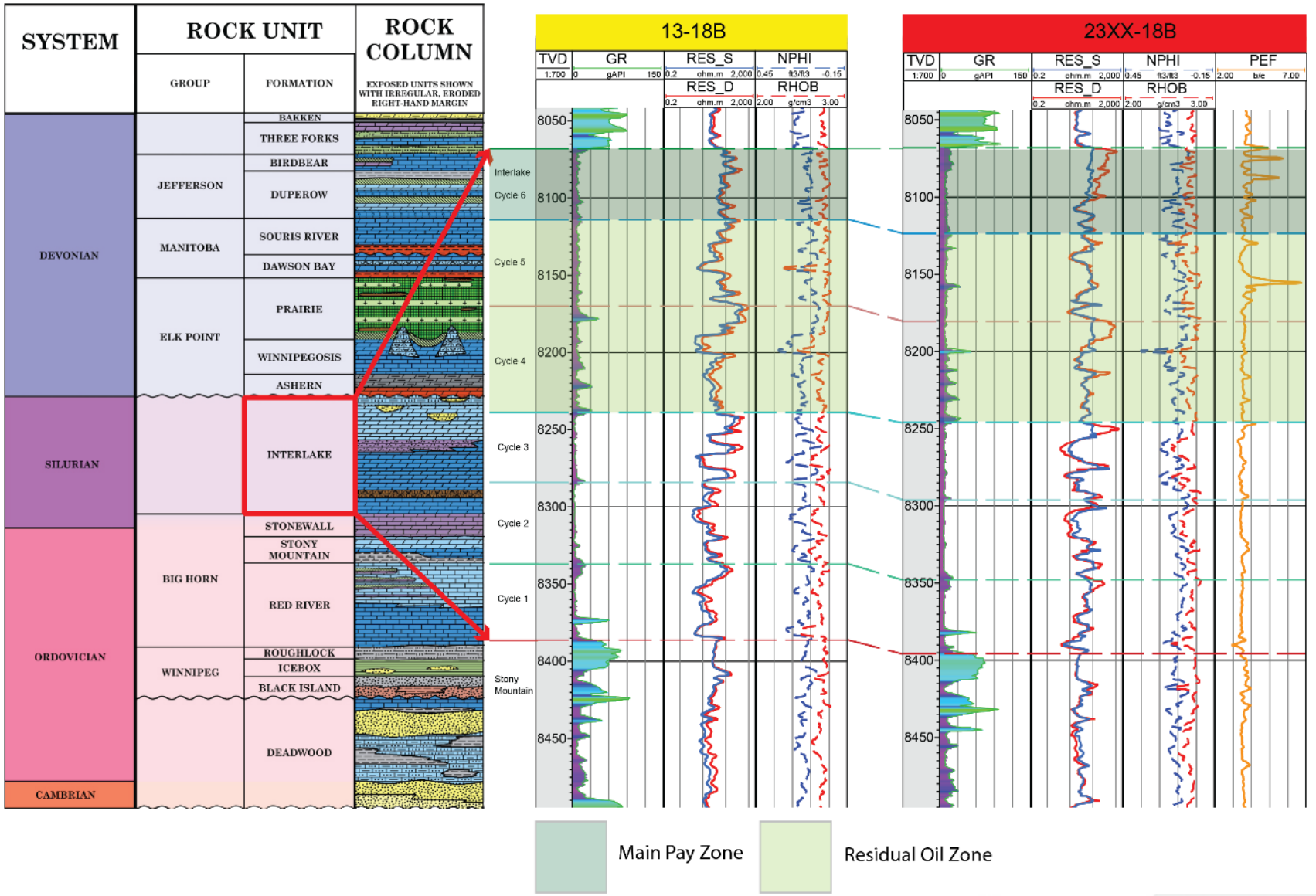
- 13-18B (producer)
- 23X-18B (injector)

Additional legacy wells are used to develop a geologic model



Target Reservoir

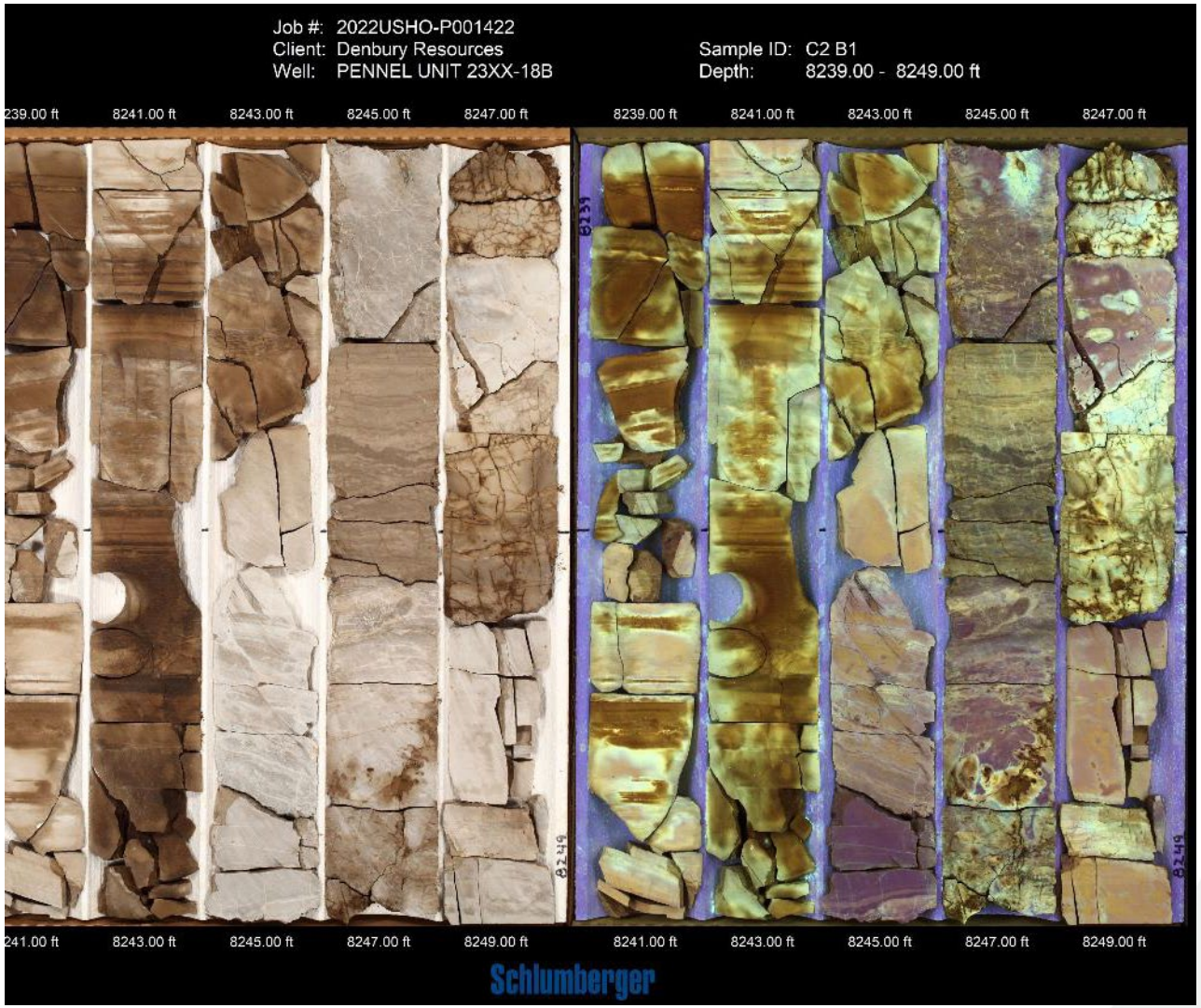
- Interlake Formation
  - Upper Interlake – main pay zone
  - Cycles 4 and 5 ROZs
- 150 ft thick
- Porosity: 1.3–16.3%
- Permeability: 0.008–3.7 mD



Core Characterization

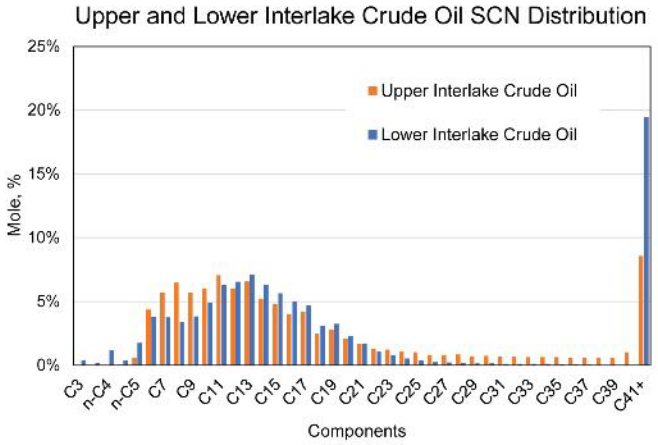
- Denbury drilled the 23X-18B (injector) and collected core over the main pay and ROZs

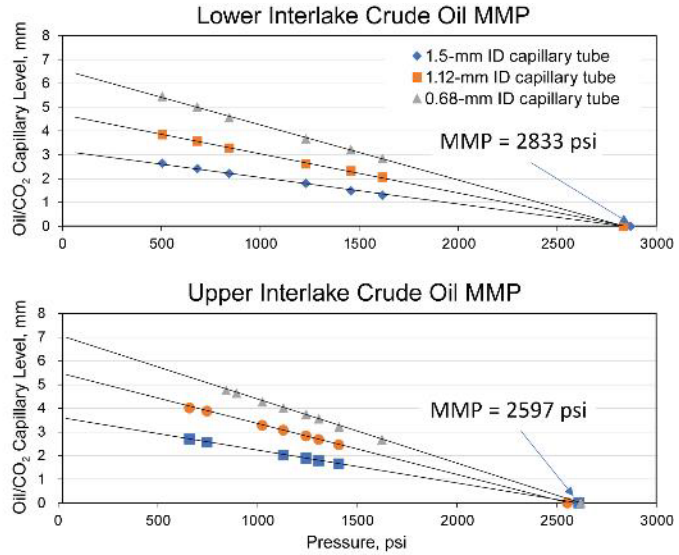
- Core analyses include:
  - Porosity & Permeability
  - X-ray diffraction
  - Mercury injection capillary pressure
  - Fluid saturations
  - Nuclear magnetic resonance
  - Special core analysis



Fluid Studies

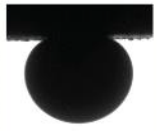
- Whole crude analysis
- CO_2 minimum miscibility pressure (MMP)
- Contact angle
- Interfacial tension (IFT)





Lower Interlake Crude Oil Contact Angle

Surrounding Phase Temperature	Produced Brine 200°F	
	Pressure, psi	Contact Angle, °
	3000	140.47
	3300	140.35
	3600	140.14
	3900	140.05
	4200	139.84



Surrounding Phase Temperature	Carbonated Brine 200°F	
	Pressure, psi	Contact Angle, °
	3000	148.02
	3300	148.04
	3600	147.85
	3900	147.48
	4200	147.36

Lower Interlake Crude Oil IFT

Surrounding Phase Temperature	Produced Brine 200°F	
	Pressure, psi	IFT, mN/m
	3000	12.82
	3300	12.60
	3600	12.52
	3900	12.47
	4200	12.40

Surrounding Phase Temperature	Carbonated Brine 200°F	
	Pressure, psi	IFT, mN/m
	3000	14.09
	3300	14.07
	3600	14.05
	3900	14.01
	4200	14.03

Upper Interlake Crude Oil Contact Angle

Surrounding Phase Temperature	Produced Brine 200°F	
	Pressure, psi	Contact Angle, °
	3000	120.53
	3300	120.12
	3600	119.75
	3900	119.47
	4200	119.27

Surrounding Phase Temperature	Carbonated Brine 200°F	
	Pressure, psi	Contact Angle, °
	3000	145.03
	3300	144.46
	3600	144.70
	3900	144.62
	4200	144.25

Upper Interlake Crude Oil IFT

Surrounding Phase Temperature	Produced Brine 200°F	
	Pressure, psi	IFT, mN/m
	3000	7.28
	3300	7.00
	3600	6.71
	3900	6.16
	4200	6.07

Surrounding Phase Temperature	Carbonated Brine 200°F	
	Pressure, psi	IFT, mN/m
	3000	9.89
	3300	9.77
	3600	9.54
	3900	9.32
	4200	9.06

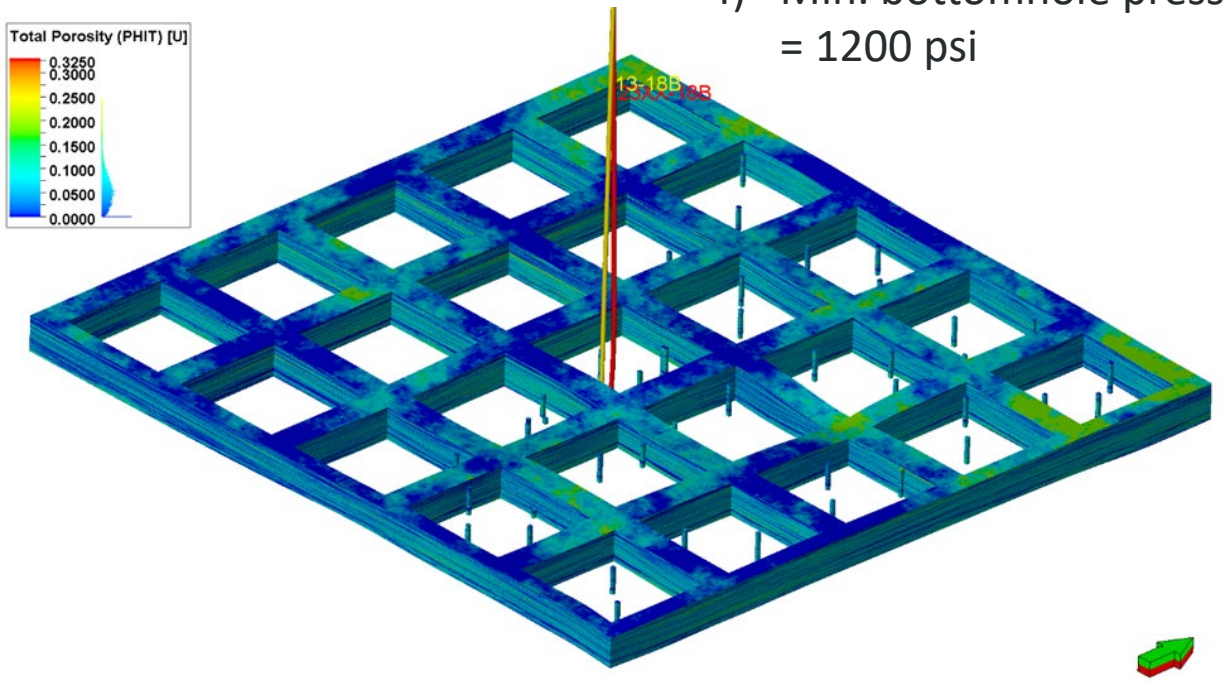
Geologic Model and Simulation

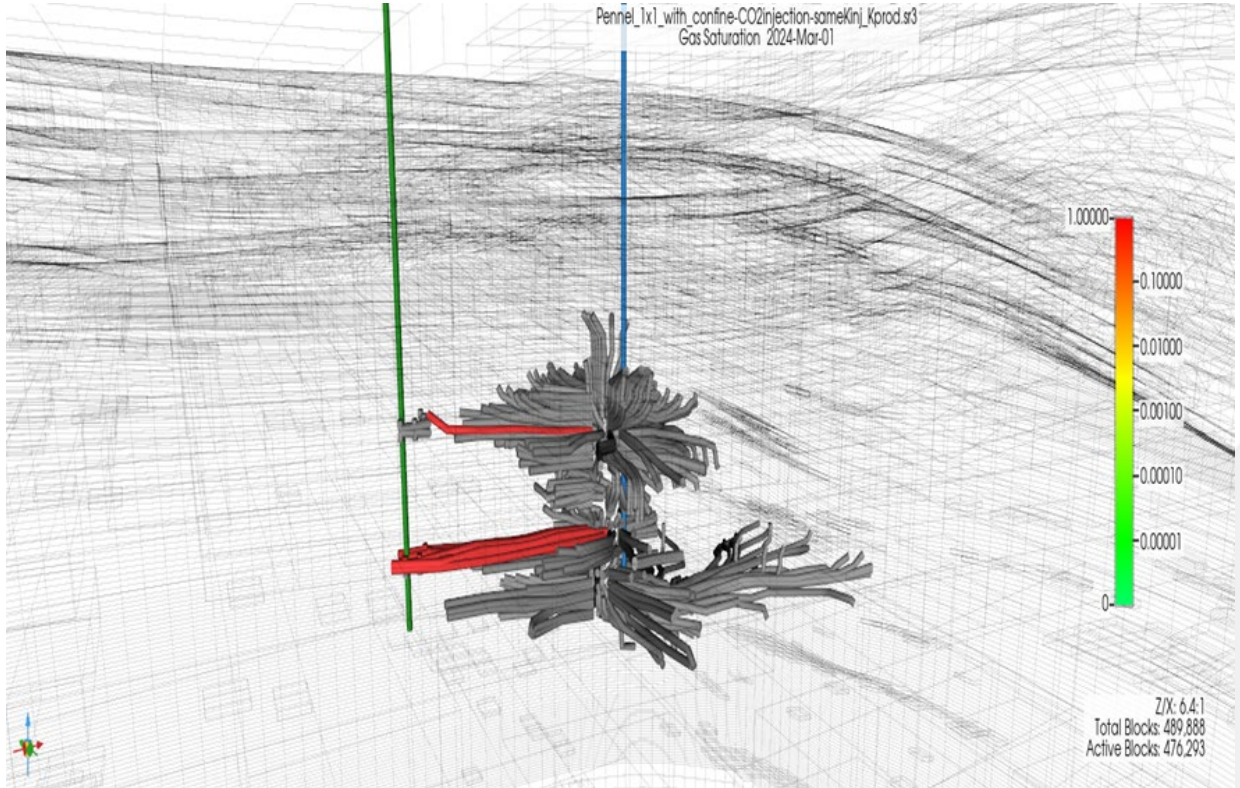
Model developed using:

- Core data
- Legacy well data

1) Max. injection = 5 MMcfpd
2) Max. bottomhole injection pressure = 6000 psi
3) Max. production =
   a. 5 MMcfpd
   b. 2000 BWPD
   c. 500 BOPD
4) Min. bottomhole pressure = 1200 psi

- Simulations are still ongoing.
- This view shows CO_2 breakthrough occurring approximately 2 months after injection begins.
- Simulations will be updated as injection and production data is received.

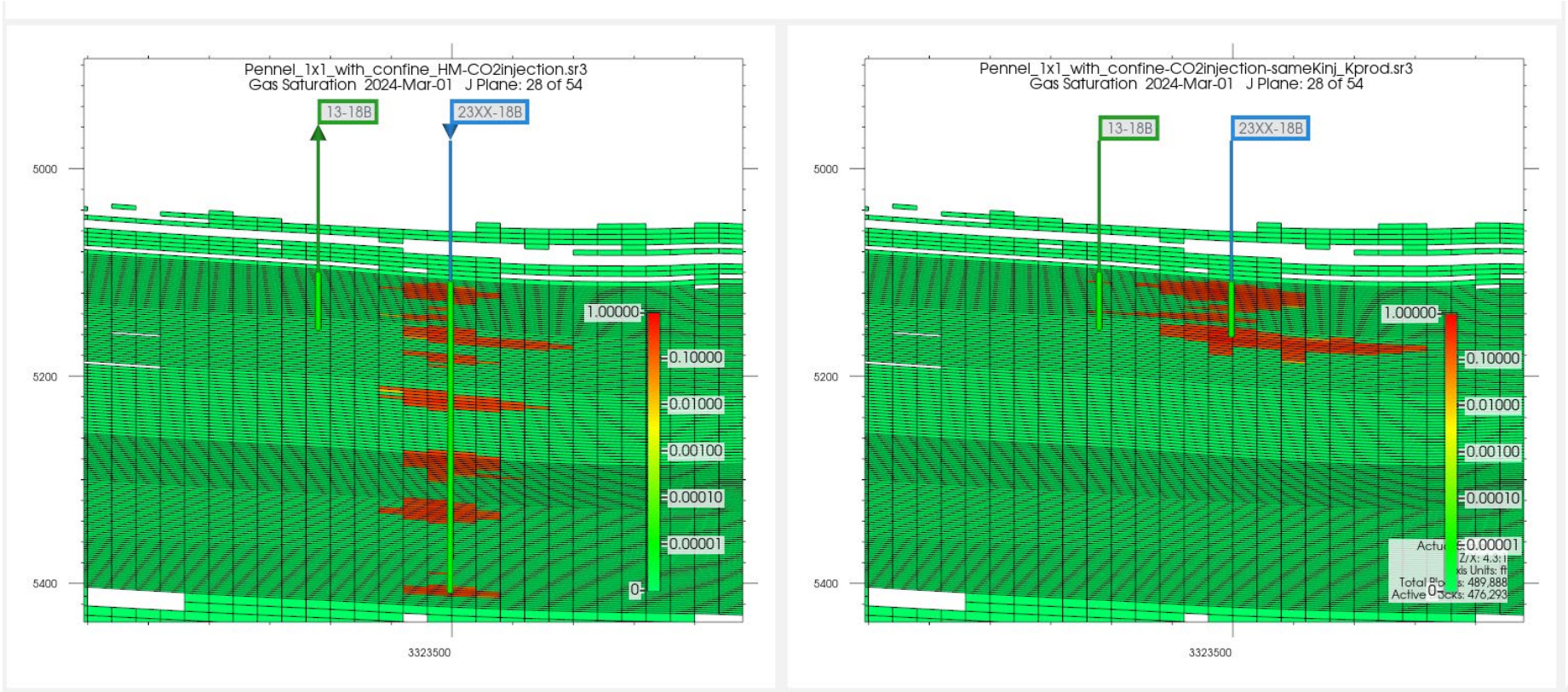




Gas Saturation

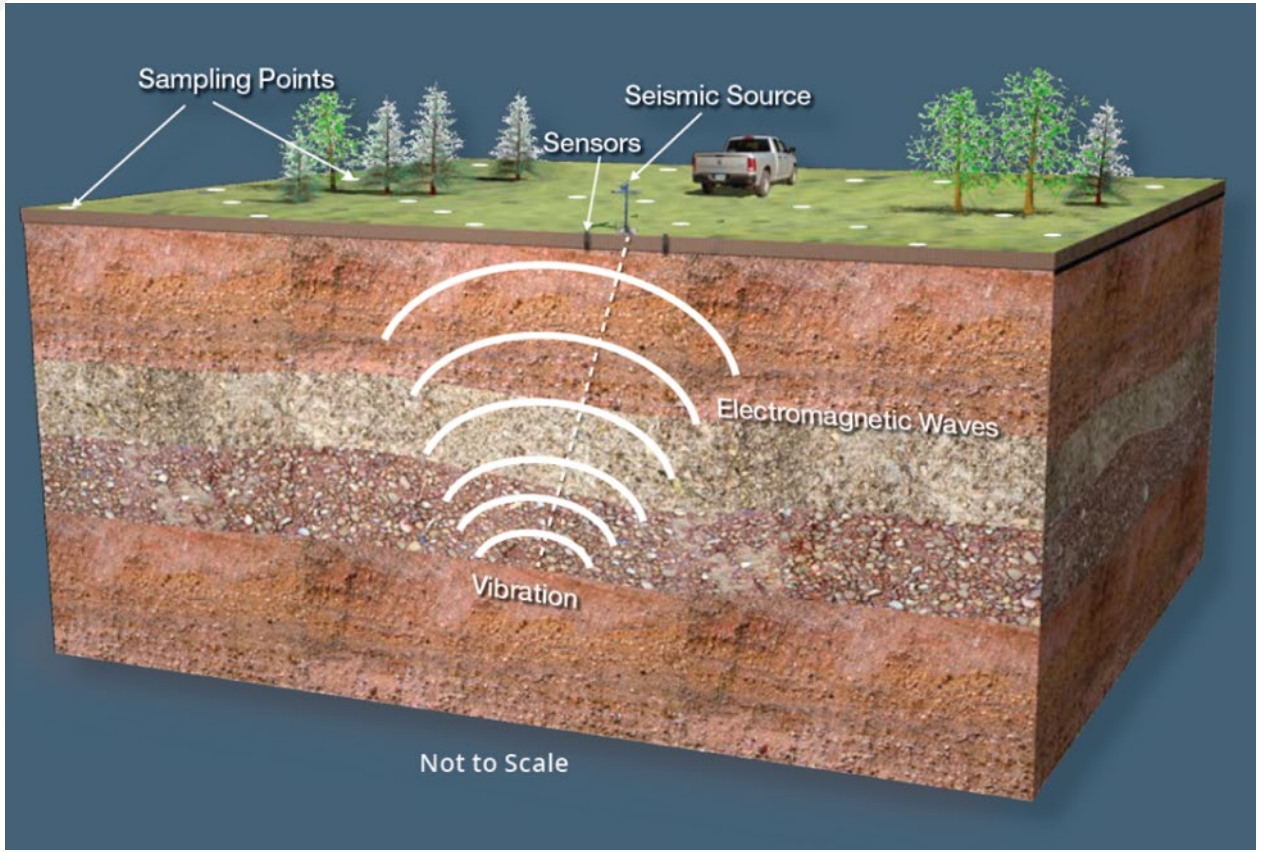
The gas is shown to break through in March when injector is at the same depth as the production well

Gas saturation
March 1, 2024



Monitoring

Traditional seismic
Fiber optics
Active seismoelectric (ASE)



ASE Technology Demonstration

Conducted over a select area of the stacked storage complex in the project field test area

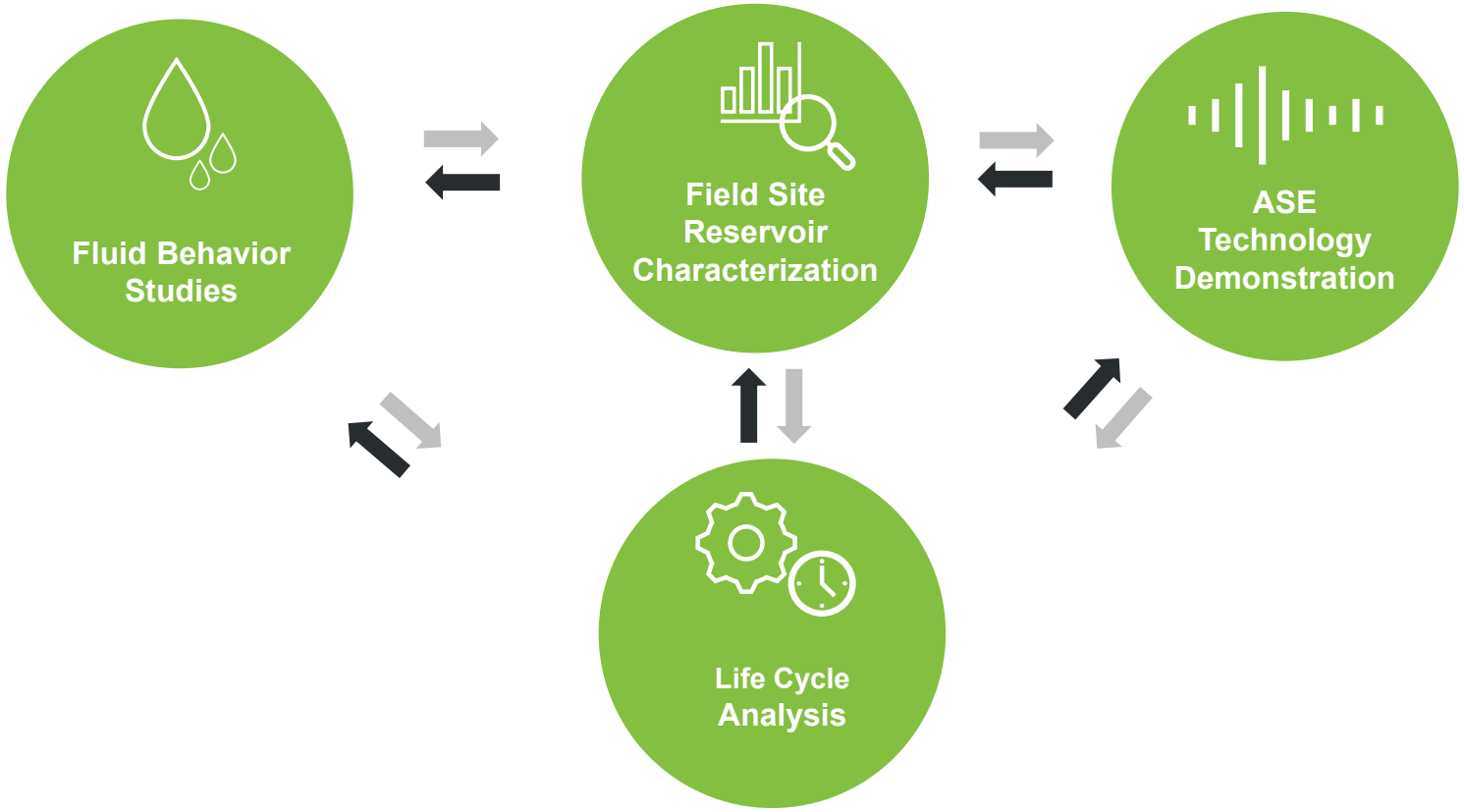
Significant accomplishments:

- Performed a small-scale ASE survey in Mentor, Minnesota, to refine field deployment strategies and examine the data processing workflow.
- Surface vibroseis sourcing and near-surface impulse sources in a high-density array were recorded.
- Collected ASE data were processed using Zonge software to remove noise and enhance seismoelectric signal.
- Initial analysis was carried out on subsets of the ASE data collected in the initial survey. Interpretation of the ASE data is ongoing.

Life Cycle Analysis

Budget Period (BP) 1 and BP2 data generated during the following tasks will be used to conduct a life cycle analysis (LCA) of the project field test:

- Fluid behavior studies
- Field site reservoir characterization
- ASE technology demonstration
- Additional data obtained from active CO_2 storage projects in North Dakota



LCA will use programs like openLCA or GREET, and will adapt our existing models for CO2-EOR, which were developed from NETL materials with site-specific adjustments

Summary

BP1

- Determined the baseline reservoir characteristics of the stacked storage complex
- Determined the effects of hydrocarbon gas impurities in the recycled CO_2 stream from stacked reservoirs on the optimization of CO_2 EOR and associated storage
- Predicted seismoelectric response based on a forward model and acquire a baseline ASE survey across the study field

BP1 (Denbury site)
Start date: April 1, 2022
End date: March 31, 2023

Summary

BP2

- Determine the reservoir response to pilot injection in a stacked complex in the context of associated CO_2 storage.
- Determine the effectiveness of ASE technology for ROZ characterization and MVA in a stacked storage complex.
- Conduct detailed LCAs of the project field injection test and a hypothetical stacked storage project in the central portion of the Williston Basin.

BP2 (Denbury site)
Start date: April 1, 2023
End date: September 30, 2025

ACKNOWLEDGMENT

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DISCLAIMER

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