HERO Basalt CarbonSAFE

Carbon Storage Assurance Facility Enterprise
(CARBONSAFE) Phase II-Storage Complex Feasibility

PROJECT AWARD #: DE-FE0032372

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U.S. Department of Energy
National Energy Technology Laboratory
Carbon Management Project Review Meeting
August 28 – September 1, 2023
CARBON TRANSPORT AND STORAGE BREAKOUT SESSION 1
Wednesday 3:45pm, Ballroom B

Pacific Northwest NATIONAL LABORATORY

UNIVERSITY OF WYOMING | School of Energy Resources

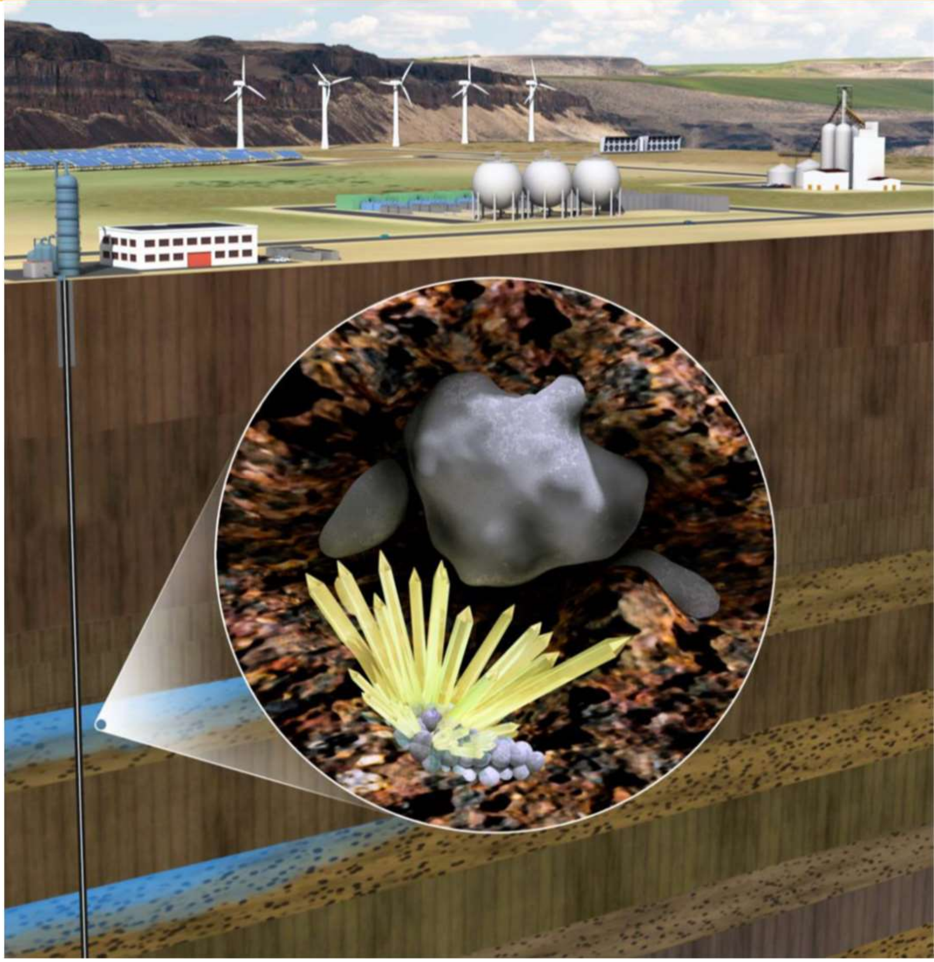
Project Overview

THE WORLD NEEDS MORE ADVENTUROUS SPIRIT.

Project Overview: HERO Basalt CarbonSAFE, Phase II

Project Summary: HERO Basalt CarbonSAFE Phase II will accelerate scale-up and deployment of CO_2 capture and storage projects in basaltic rocks—the largest potential CO_2 storage resource in the Pacific Northwest.

Duration: 2 years, *currently in award negotiations*



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Project Location

Calpine's Hermiston Power Project

- Located in a rural area of the Deschutes-Columbia Plateau
- Two turbine natural gas facility
- Operating since August 2002
- 566 megawatts baseload
- ~1.7 million metric tons/annum
- Markets in the Pacific Northwest and California
- One of the State's cleanest gas facilities
- Offers quick response to grid needs, so it is helping to balance the integration of the region's wind resources with less impacts to the grid

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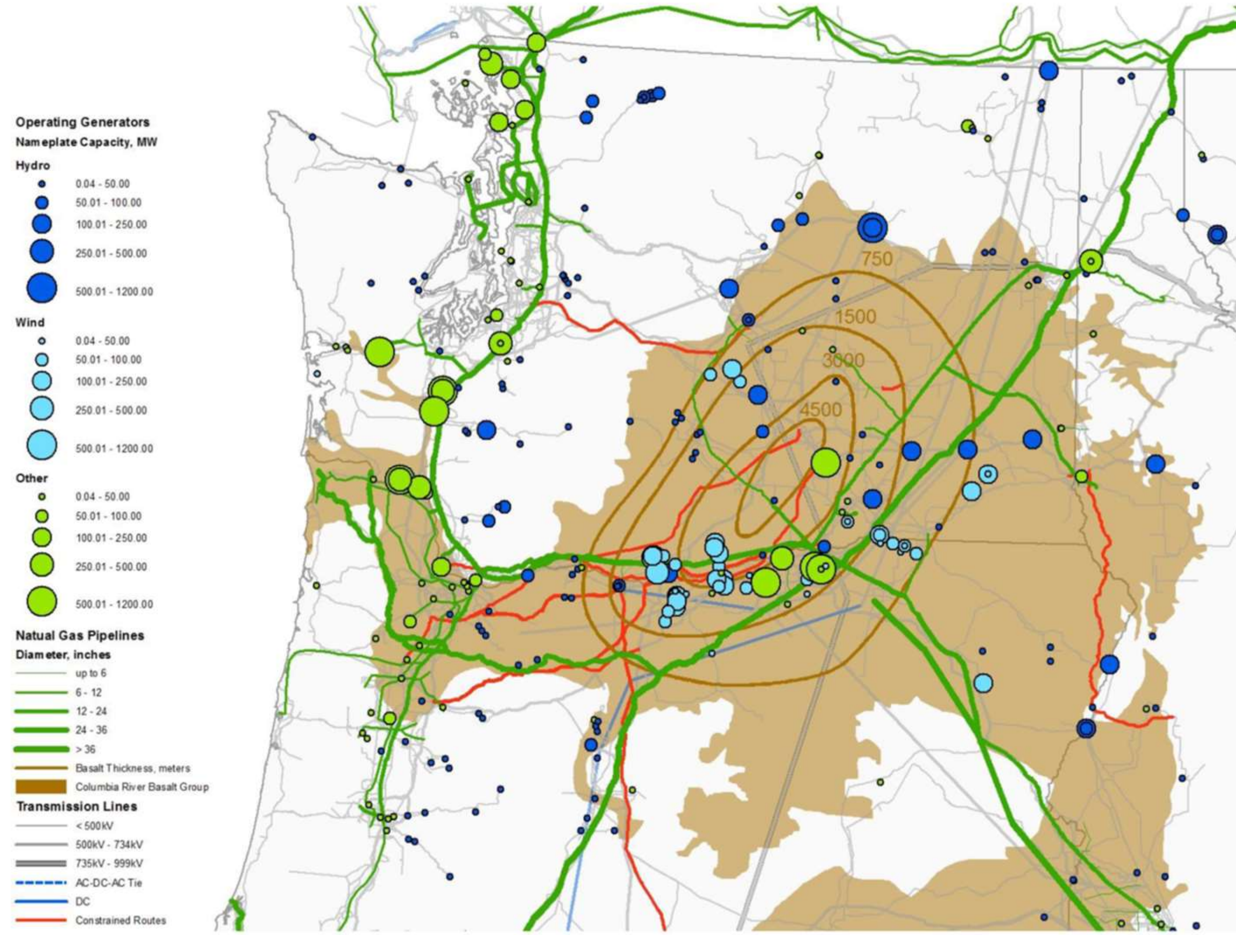
Project Background

Benefit to the Northwest

- Limited carbon management/storage solutions without basalt
- Provides options to manage Scope 3 emissions on-location
- There are limited studies on basalt injection and mineralization; this project will provide invaluable scientific, community impact, regional regulatory and operational lessons



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Project Background

Benefit to the CarbonSAFE Program

1. Effectively doubles the data and analysis performed to-date on deep basalt formations in the US

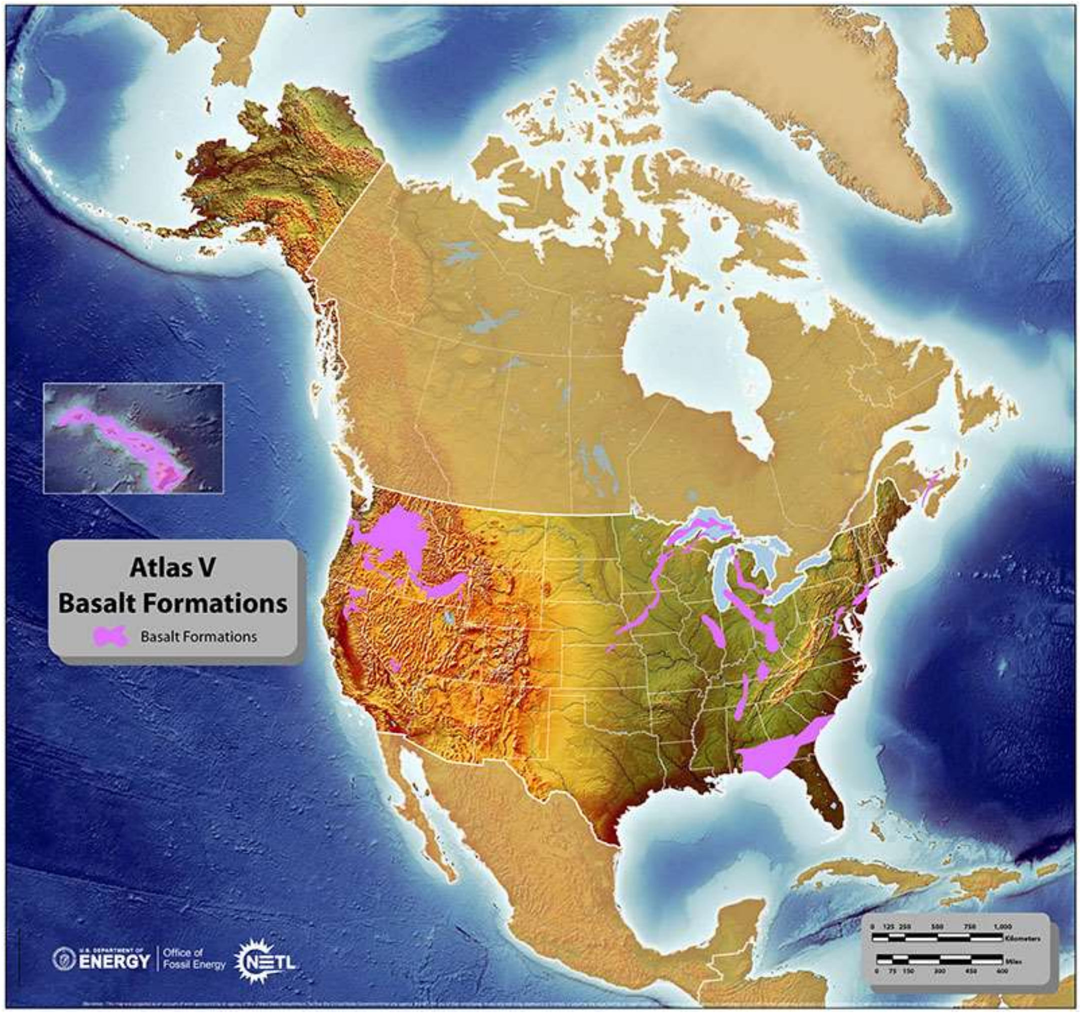
2. Help to refine CCS characterization methodology for basalts

3. Help to define field operation and completion methods, economics, and risk

4. Help to refine mineralization kinetics relative to commercial geologic storage and risk

5. Assessment of regulatory requirements in a region of the US with relatively minimal activity to-date

6. Continued development of Pacific Northwest-focused outreach and education



Technical Approach

THE WORLD NEEDS MORE COWBOYS.

Technical Approach

1. **Societal Considerations and Impacts Assessment and Plans**

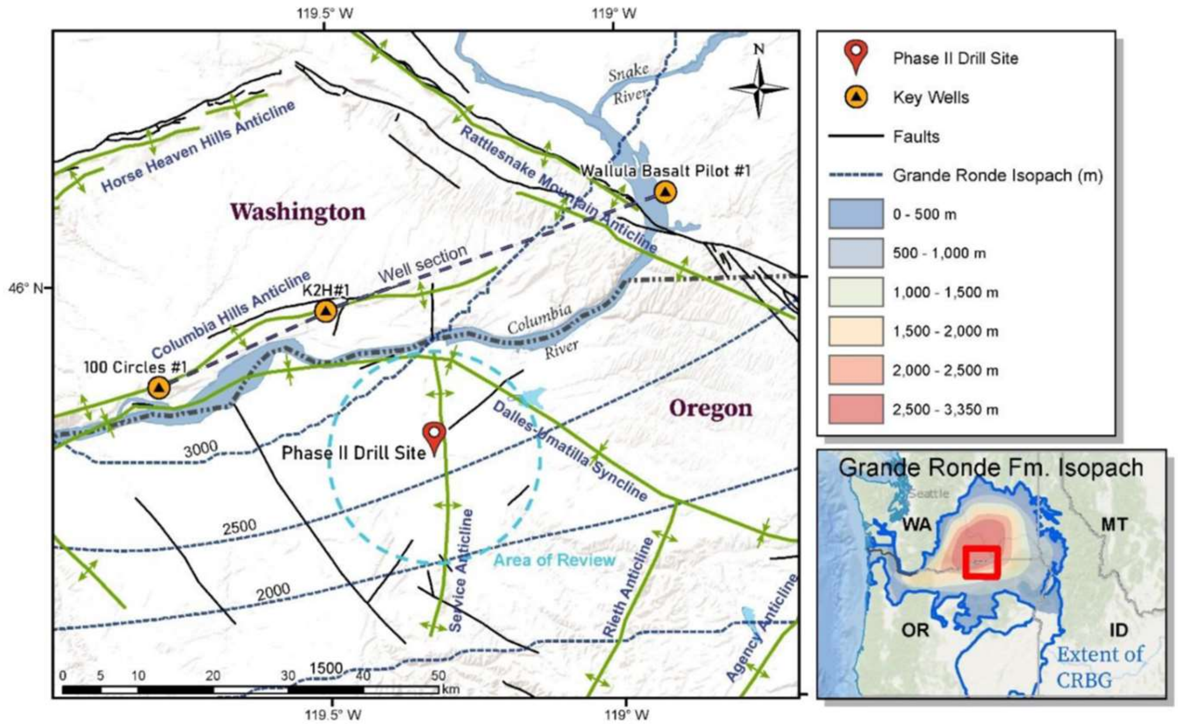
2. **Field Operations**
   - **Permitting**
   - **Site preparation**
   - **Drill and sample stratigraphic test well**

3. **Data Analysis and Modeling**

4. **Commercial Feasibility Assessments**

5. **Science-Forward Characterization Program**

6. **Extend Learnings from Wallula to expedite Permitting, Reservoir Modeling, Data Acquisition, and Operations**



Project Partners

University of Wyoming School of Energy Resources	Project Management, Data and Regulatory Analysis, Commercial Assessment
Pacific Northwest National Laboratory	Data Analysis, Societal Considerations, Simulations, Commercial Assessment
1POINTFIVE	Field Operations and Data Analysis
CALPINE®	Site Host, CO_2 Source, Commercial Assessment
Carbfix	Basalt Storage Assessments and Outreach
Schlumberger	Field Operations and Data Analysis

Milestones and Risk

Key milestones

1. Successful community engagement and outreach
2. Complete access agreements and permitting for field operations
3. Stratigraphic test well completion and sampling
4. Mineralization assessment and simulations of storage capacity and risk
5. Commercial assessments

Project risks

1. Public acceptance
2. Completion of the drilling and sampling program
3. Costs

Basalt Sequestration Science

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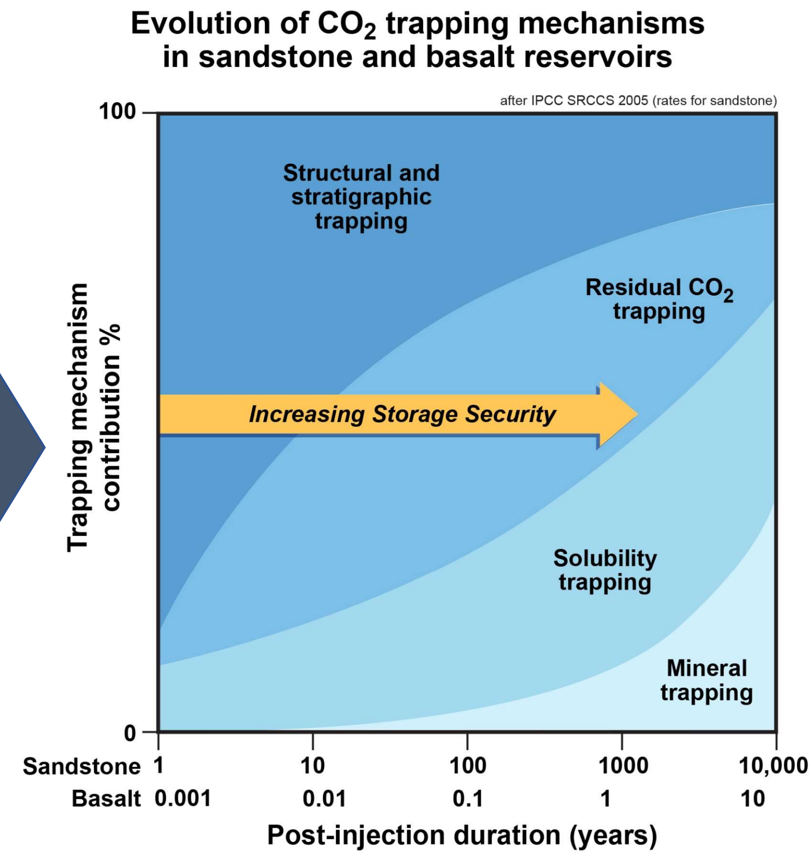
Perspective on CO_2 Sequestration in Basalts

- Laboratory studies at PNNL confirmed rapid carbonation (2006)
- First field evidence of *in situ* carbonation occurring from a free phase supercritical CO_2 injection into a flood basalt reservoir (2015)
- Hydrologic modeling approach for tracing extent of mineralization (2021)
- Basalt systems offer the most realistic chance of a paradigm shift in the conventional view of risk profile of CCS



Basalts **convert CO_2 to solid minerals** much more rapidly than other rock types. Mineralized CO_2 is immobile and poses **no risk of leakage.**

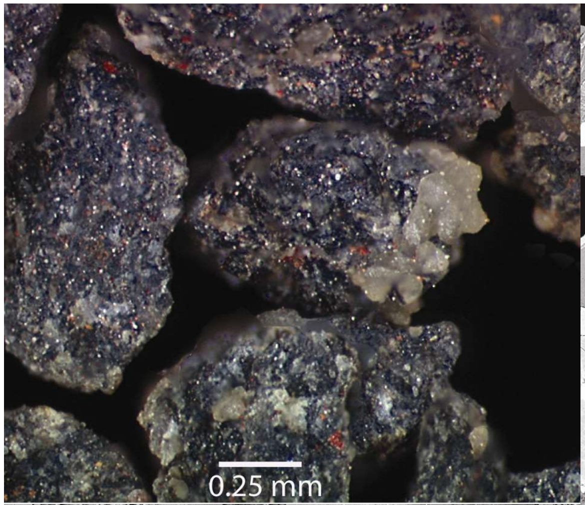
Discrete Carbonation Products Form Through Exposing Basalt Chips with CO_2-Water

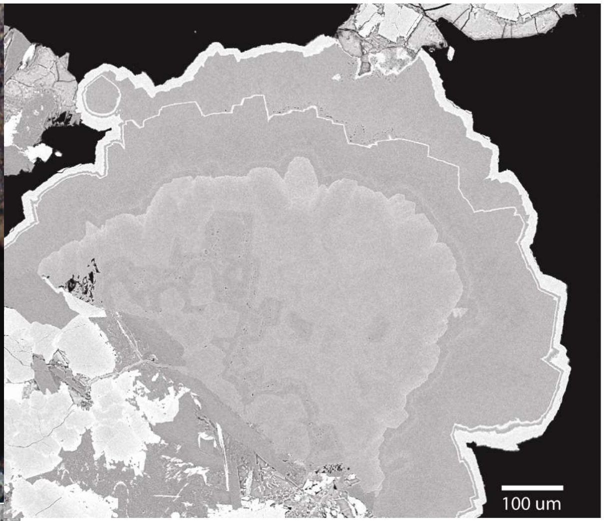
Experimental Derived Data

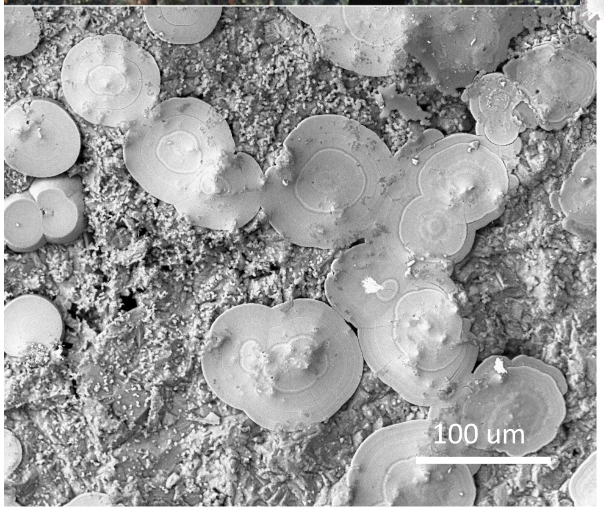
- reaction products
  - Calcite
  - Aragonite
  - Rhodochrosite
  - Ankerite
- variable chemistry
  - Heavily substituted with Fe^{2+}, Mn^{2+}
- carbonate structure transitions with depth
- estimated carbonate rate
  - ~0.19 kg m^{-3} yr^{-1}

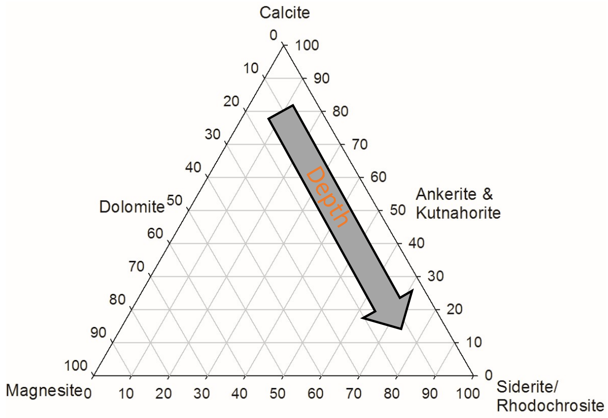
Schaef, McGrail, et al 2010, "Carbonate mineralization of volcanic province basalts", IJGGC, 1 249-261.

Xiong, Wells, Horner, Schaef, et. al., 2019. "Potential for CO_2 Sequestration in Flood Basalts", Journal of Geophysical Research, Vol 111, B12201.



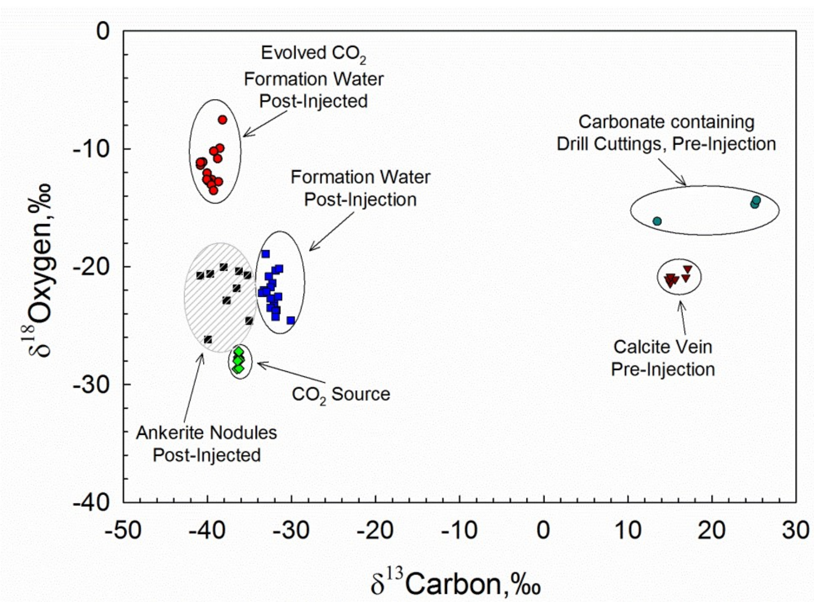


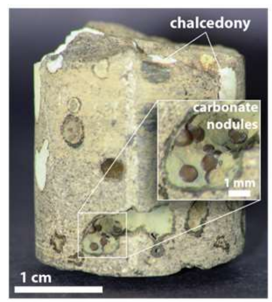




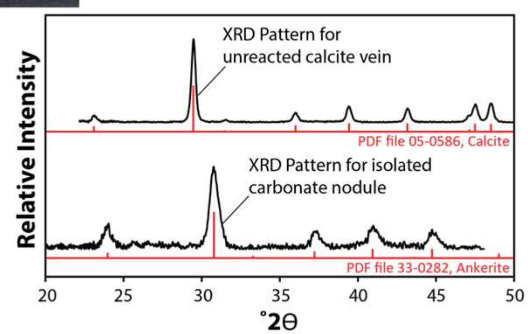
Sidewall Core Characterization Revealed Ankerite as forming CO_2 post injection

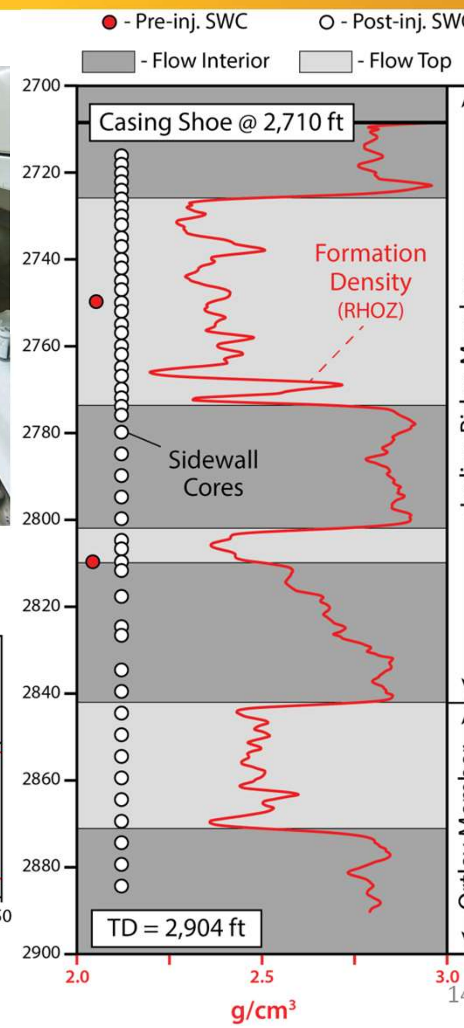
- 50 sidewall cores (SWC) were collected across the open borehole section between 827.8 to 883.9 m (2,716 – 2,900 ft bgs)
- Carbonate nodules observed on SWCs occurred both as large (up to ~1mm) nodules as a coating (cements)
- XRD of nodule material identified ankerite
- Isotopic signature confirmed the injected CO_2 was mineralized





SWC Sample

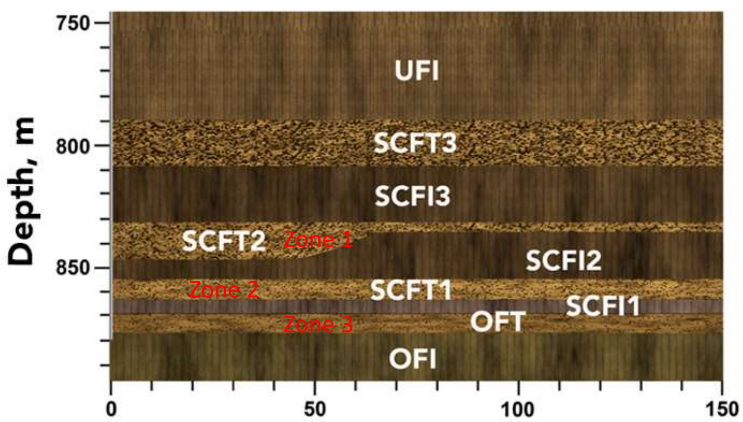




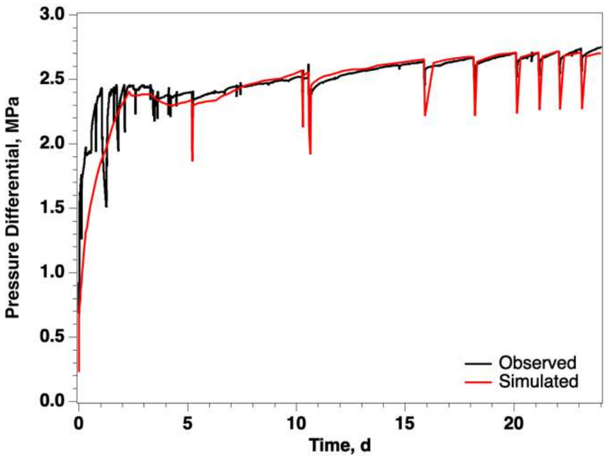
McGrail, Schaef, et al. 2017. "Field Validation of Supercritical CO_2 Reactivity with Basalts." *ES&T, Letters, 4, 6-10.*

Field-Scale Reservoir Simulations Indicate ~60% (~600 tones) of CO_2 is Converted in 24 Months

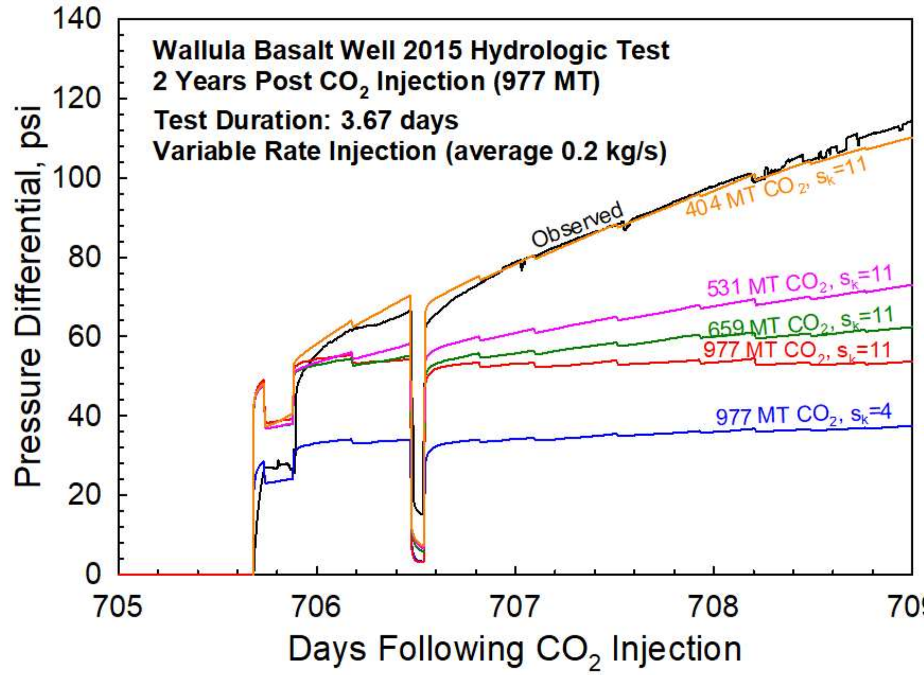
Layered basalt model properties identified from the 2012 pre-injection hydrologic test



Pressure injection response
Simulated and observed pressure buildup responses (2013 CO_2 injection) matched

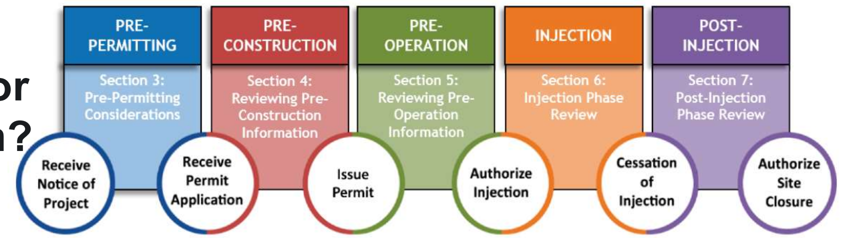


***Post-injection pressure testing**:* STOMP-CO2 reservoir simulation of post-injection pressure response with ~40% of residual CO_2 mass in the reservoir together with an increase in well skin (S_K) provided a near perfect match to observed reservoir response



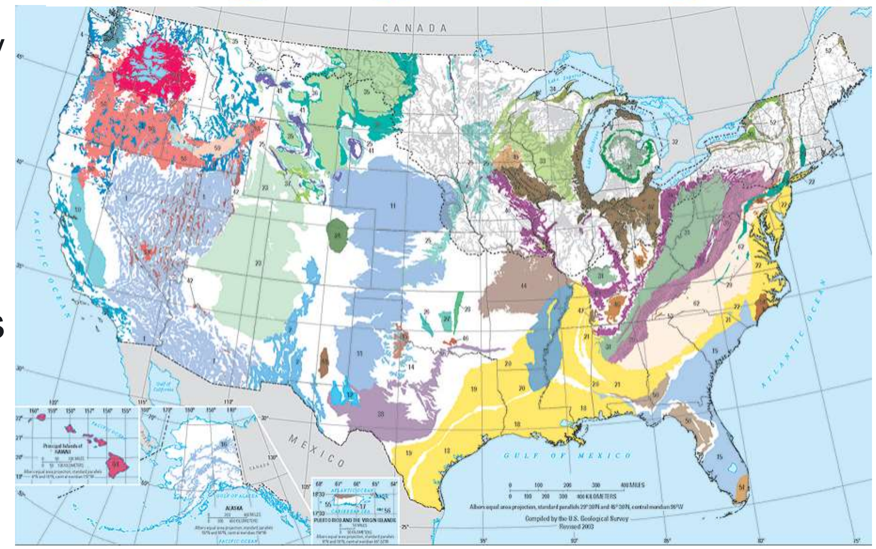
SK White, FA Spane, HT Schaef, et al., 2020. "Quantification of CO_2 Mineralization at the Wallula Basalt Pilot Project." *ES&T, 54, 14609-14616.*

Challenges for Class VI permitting Include Data Scarcity, Limited Field Demonstration Sites, and Experience



Current regulation framework is designed specifically for deep saline, but can it accommodate CO_2 mineralization?

- ✓ What does EPA need to make a determination?
- ✓ Do we need new characterization methods?
  - Pressure monitoring and geochemical sampling as primary monitoring mechanisms
  - What emerging technologies can we leverage?
- ✓ Should seismic be the gold standard?
  - Seismic as secondary or tertiary validation tool
  - Accessing existing seismic is difficult and expensive
- ✓ Attribution of pressure reductions to mineralization vs migration
- ✓ Guidance on water quality resources
  - USDW 10,000 (mg/L) TDS limit
  - Will exemptions be considered? If so, how?
  - Brine extraction/treat/reuse for pressure management



Principal aquifers of the United States (USGS)

Opportunities:

- Partner with US EPA, USGS, state surveys, et al. to address basalt-specific data needs for Class VI permitting
- Collaboration with host communities and stakeholders to understand benefits and impacts (e.g., groundwater resources).
- Leverage field demonstration sites more broadly throughout the research community by applied and fundamental science teams
- **Industry seeks regulatory and technical support for Class VI permits that account for risk reductions**

Community Benefit Plan

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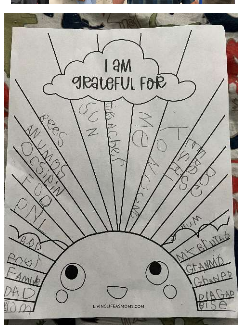
HERO CBP Strategy

- Leverage previous experience and engagement of local and regional stakeholders in shaping a community vision
  - Carbon storage in basalts can benefit the PNW
  - Nucleus for clean energy projects in the region
- Identify key stakeholders in surrounding communities
  - Work to engage stakeholders to share knowledge about CO_2 storage
  - Solicit feedback to help guide project-specific engagement on future phases HERO
  - Engage with regional regulatory entities
- Sharing and soliciting feedback from the local communities
  - Build advocacy for clean energy projects
  - Collaboratively address non-technical challenges to project development

Stakeholder and Community Outreach is Strategic for Clean Energy Project Acceptance

PNNL

- Demonstration of benefits to communities that are hosting these clean energy projects
- Early engagement is critical to gain acceptance
- Training next generation scientists from local communities (e.g., community colleges)



Summary

HERO will represent the first basalt-hosted CO_2 storage hub in the nation and the first commercial CO_2 storage project in the PNW.

Questions?

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Appendix

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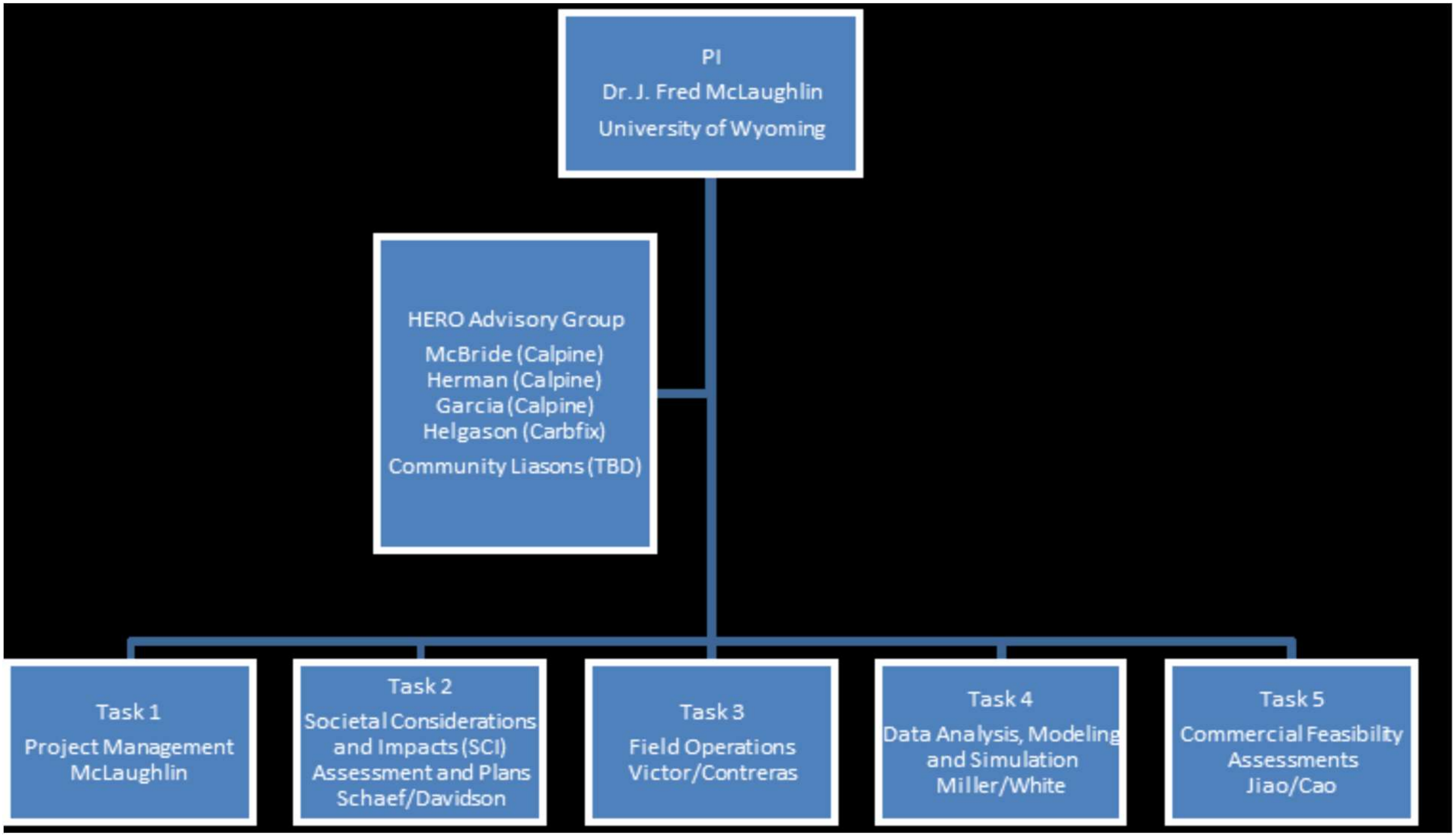
Organization Chart



Gantt Chart

Project Schedule

Calendar Year

Year 1 Year 2

WBS	Task/Milestone Title	G/N	Start	End	BP1 1	2	3	4	5	6	7	8
Task 1	**Project Management and Planning (U of Wyo)**		1	8								
Task 2	**Societal Considerations & Impacts Assessment and Plans (PNNL)**		1	8								
M2.1	Initiated outreach in Hermiston, OR (ID educators)		1	1								
M2.2	Held public outreach workshop in Hermiston, OR		2	2								
M2.3	Held all-hands project meeting on DEIA		3	3								
M2.4	Held STEM workshop in Hermiston, OR with partners (**SMART**)		4	4								
M2.5	Finalized student placement with DOE internships		6	6								
M2.6	Held community workshop with partners (**SMART**)		8	8								
Task 3	**Field Operations (OLCV)**		1	5								
M3.1	Finalized Site Access and obtain required permitting		1	1								
M3.2	Completed well pad construction & drilling Stratigraphic Well		2	2								
M3.3	Finalized logging, hydrogeologic testing, and sampling		3	3								
M3.4	Demobilized drill rig and restored drill site		4	4								
M3.5	Issued site closure and lessons learned report		5	5								
Task 4	**Data Analysis, Modeling and Simulations (PNNL)**		3	7								
M4.1	Compiled & analyzed existing regional data for conceptional		3	3								
M4.2	Parameterized model with stratigoraphic well data		4	4								
M4.3	Completed series of numerical CO_2 injection simulations		5	5								
M4.4	Finalized reactive transport modeling for mineralization		6	6								
M4.5	Issued report on CO_2 Mineralization potential for HERO		7	7								
Task 5	**Commercial Feasibility Assessments (UWyo)**		4	8								
M5.1	Completed scenario Analysis		4	4								
M5.2	Finalized report on technical subsurface data evaluation		5	5								
M5.3	Conducted regional analysis on CO_2 Hub at HERO site		6	6								
M5.4	CO_2 Technical Analysis		7	7								
M5.5	Issued report on stakeholder analysis outcomes for HERO		8	8								

Project Funding

Spend Plan by Fiscal Year Format

	FY 2023		FY 2024		Total	
	DOE Funds	Cost Share	DOE Funds	Cost Share	DOE Funds	Cost Share
UWyo	559,379.50	83,617	559,379.50	83,617.00	1,118,759.00	167,233.50
OLCVS	2,994,469	600,00.00	3,250,000.00	600,000.00	5,988,938.00	1,200,000.00
PNNL	650,000.00	75,000.00	650,000.00	75,000.00	1,300,000.00	150,000.00
Calpine	0	160,000.00	0	160,000.00	0	320,000.00
CarbFix	0	25,000.00	0	25,000.00	0	50,000.00
Schlumberger	0	115,000.00	0	115,000.00	0	230,000.00
Total ($)	3,996,453.00	1,058,617.00	3,996,453.00	1,058,616.50	8,407,697.00	2,117,233.00
Total Cost Share %		20%		20%		20%