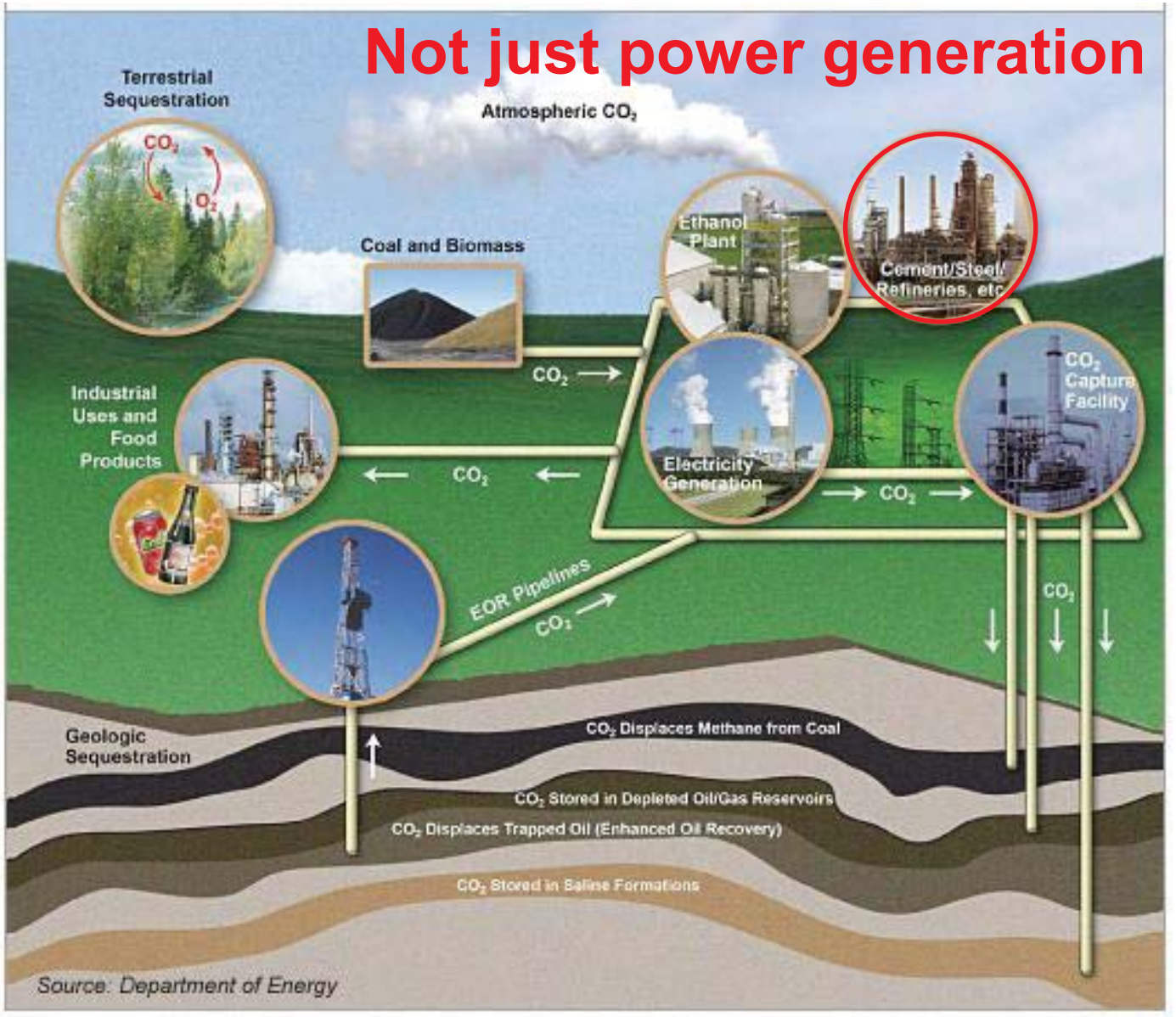
Research, challenges and opportunities to reduce carbon emissions in fossil fuels

Lee H. Spangler, Director
The Energy Research Institute
Montana State University

What is CCS (Carbon Capture and Storage)?



CO_2 Emission Sources in the Northwest US

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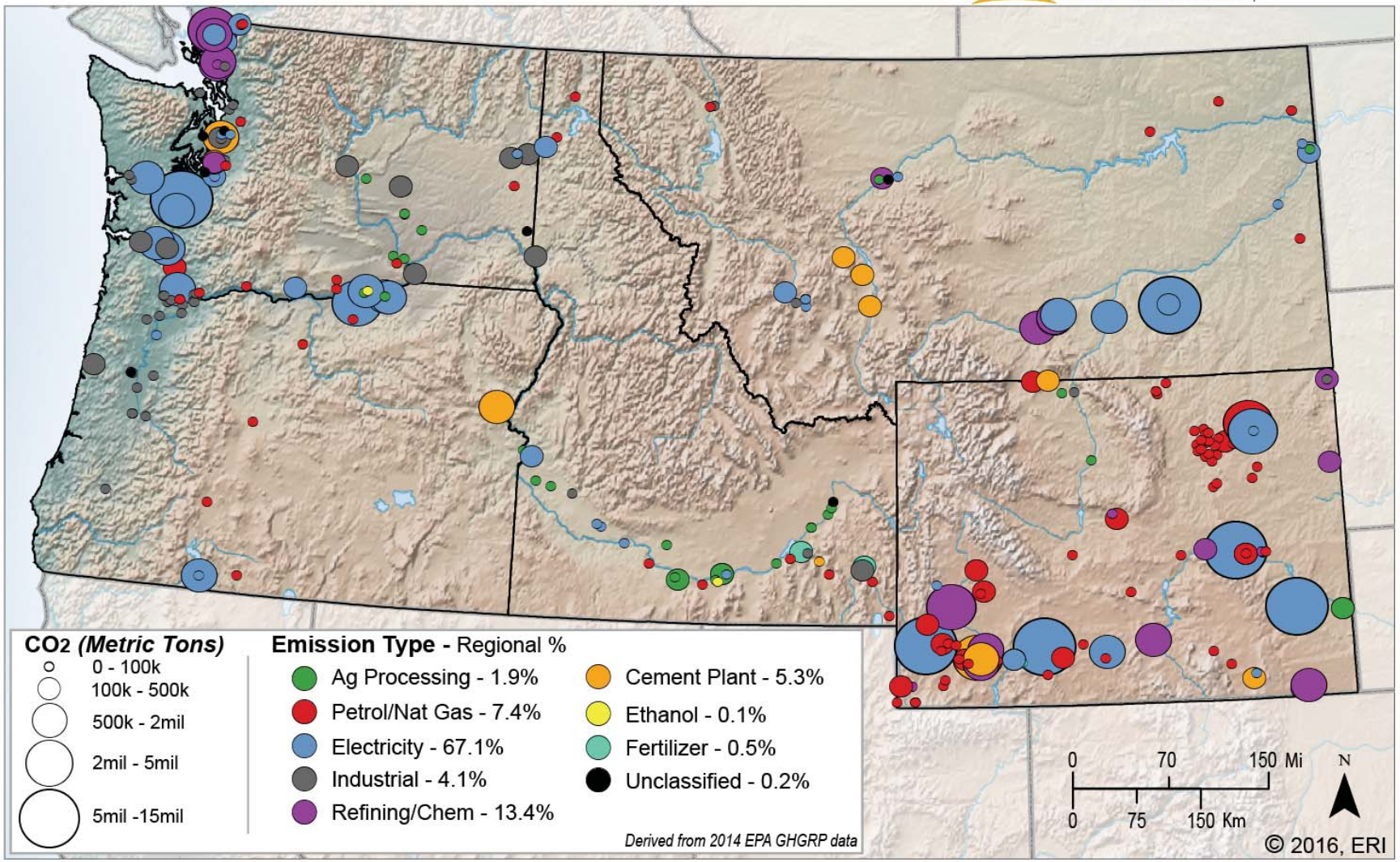
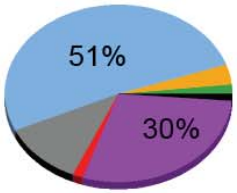
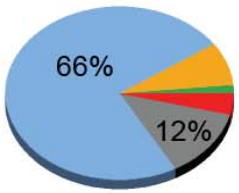
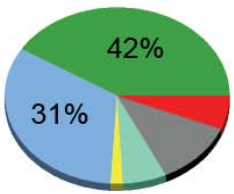




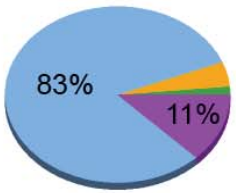
22,711,670 T



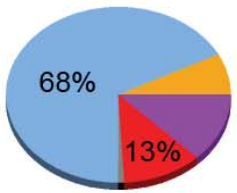
10,733,180 T



3,119,112 T

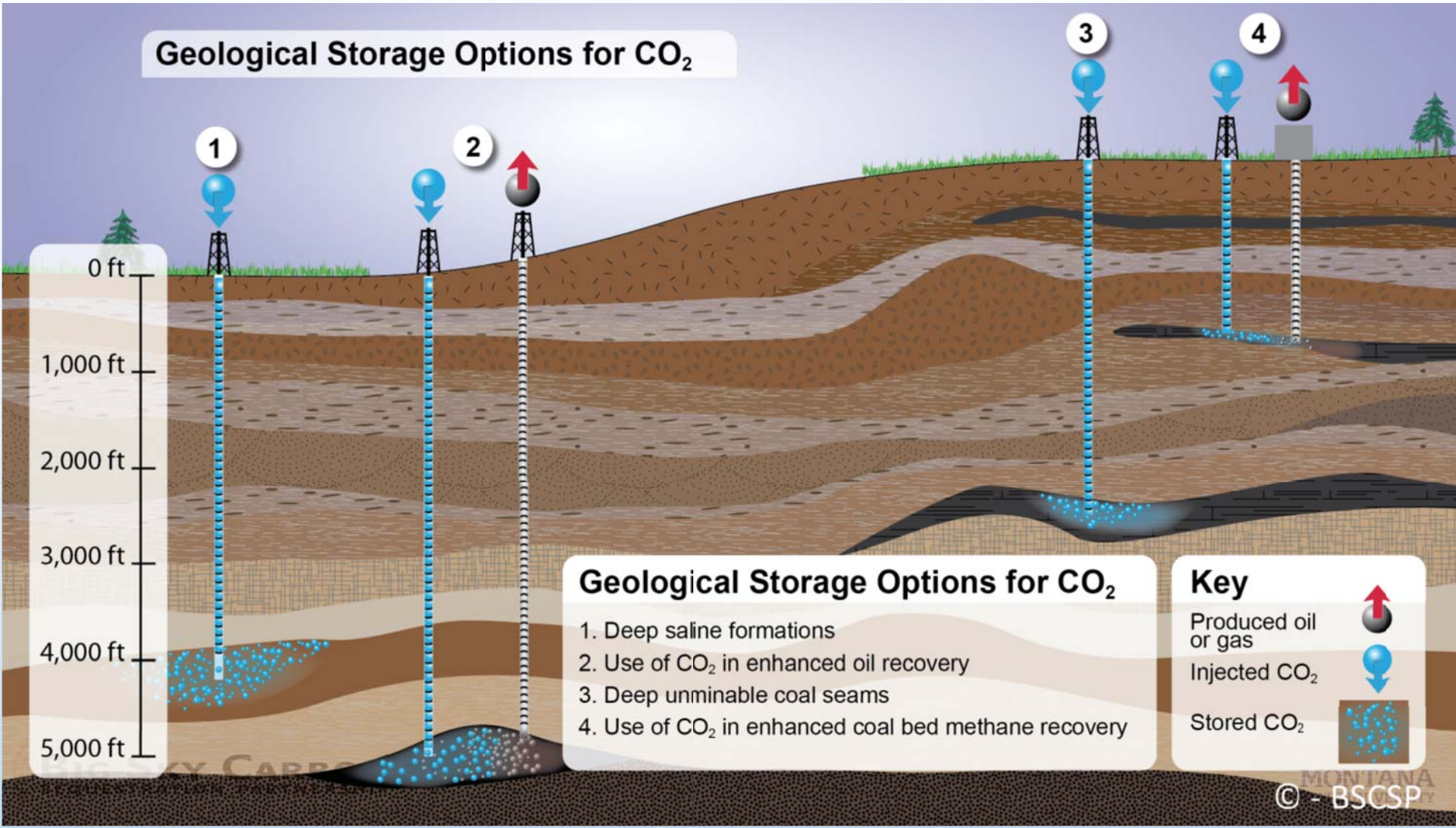


22,045,404 T

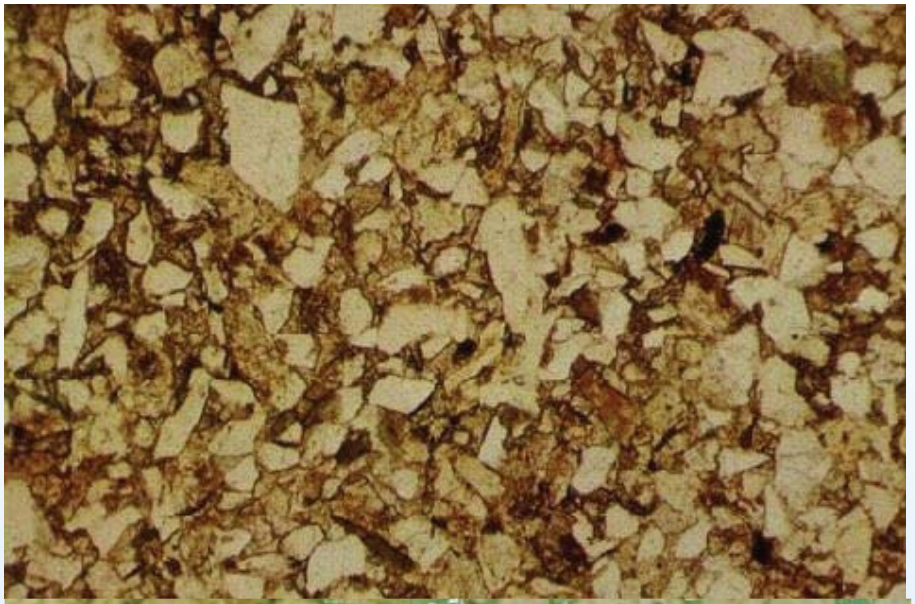


62,063,809 T

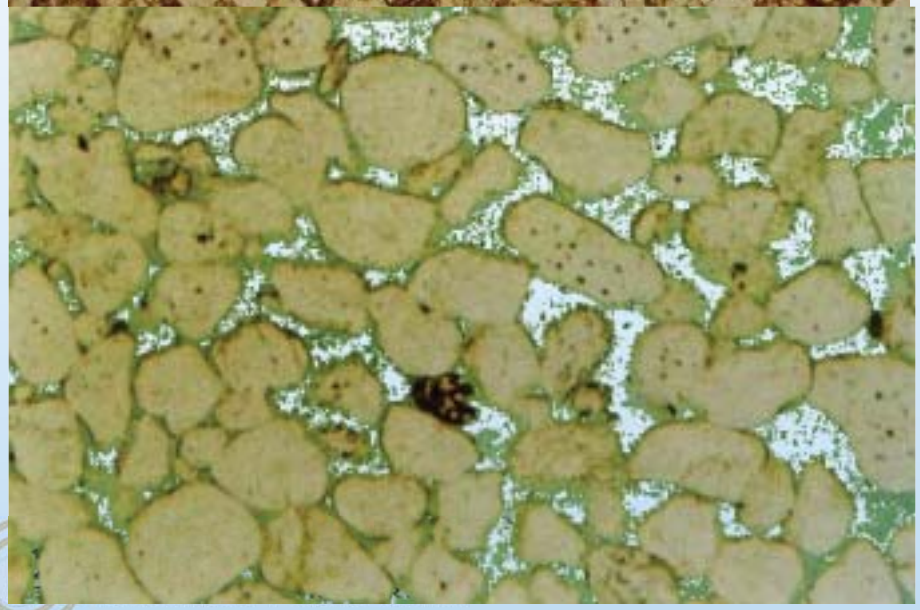
Carbon Capture and Storage



Key Geologic Layers



Tight “Cap Rock”



Porous “Reservoir”

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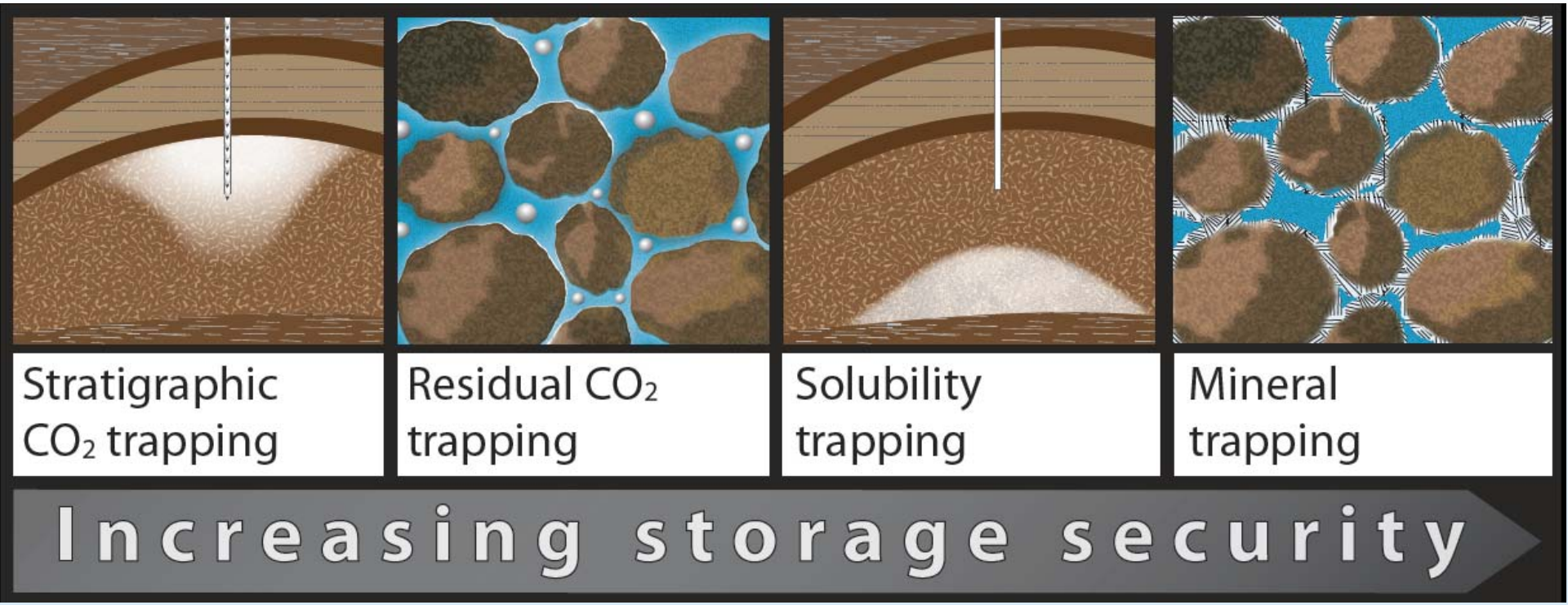
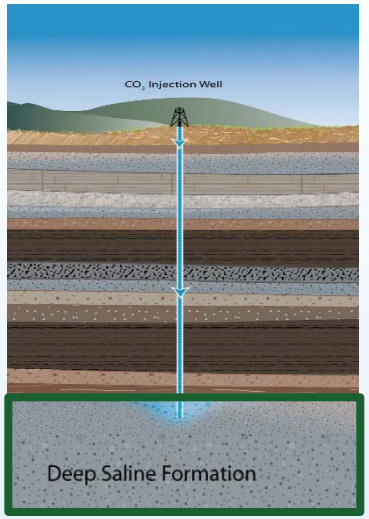
Trapping Mechanisms



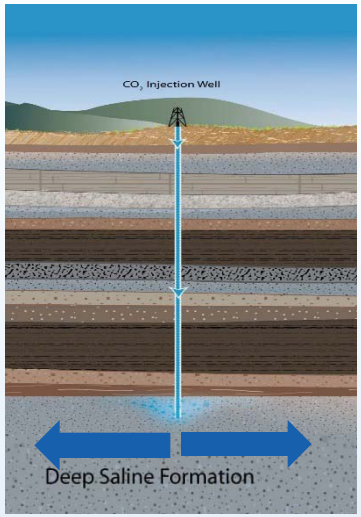
Requirements for Storage

Capacity



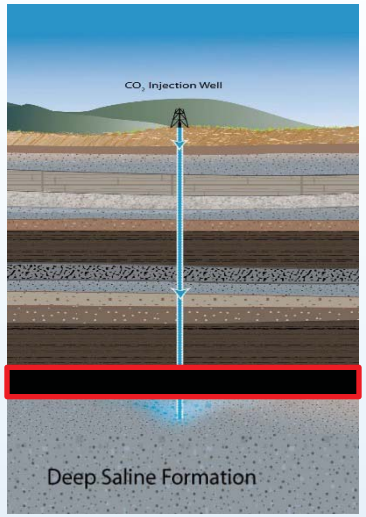
- Formation thickness
- Areal extent
- Porosity
- Compartment size
- Water Quality

Injectivity



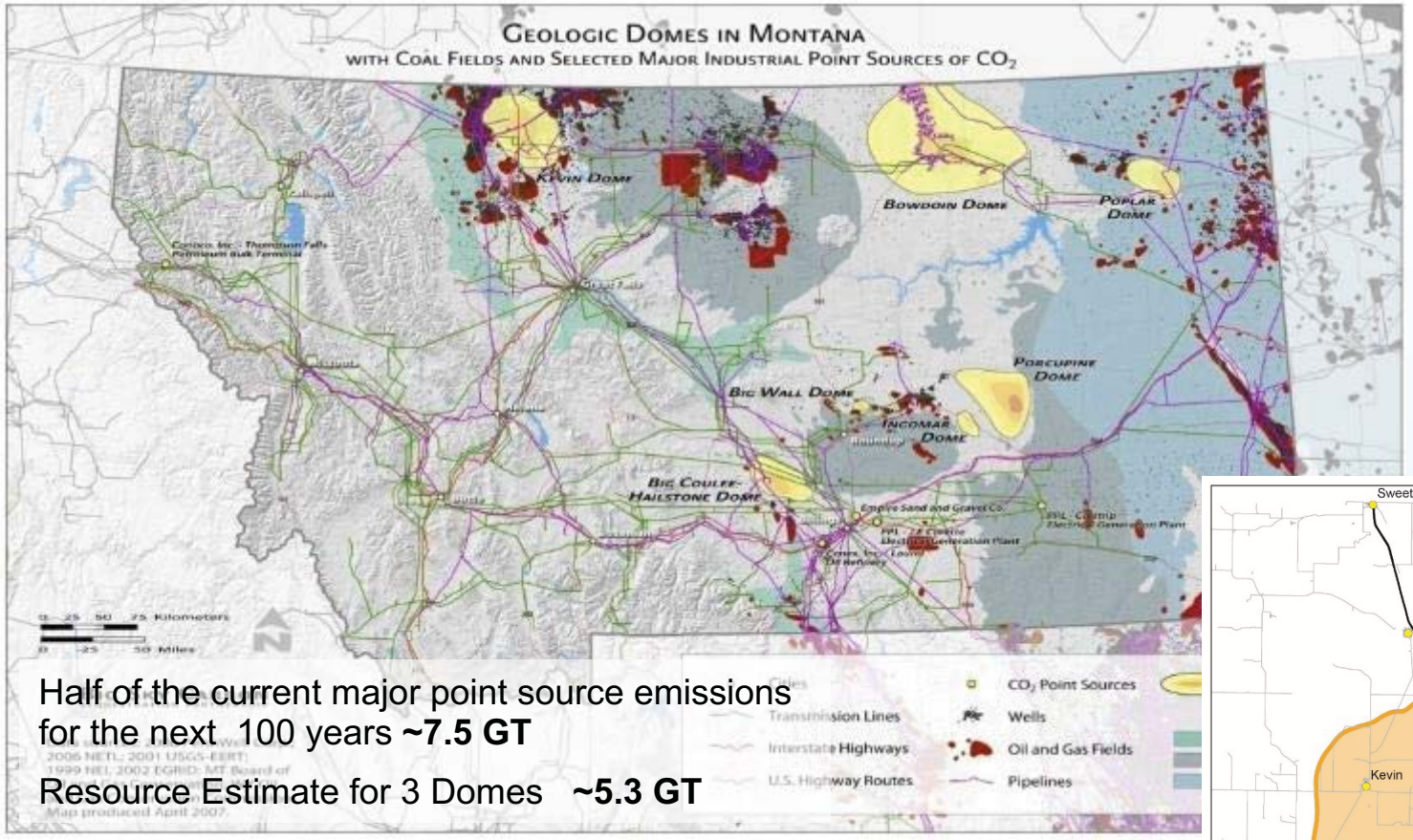
- Permeability
- Compartment size
- Geochemistry
- Mechanical properties

Storage Security



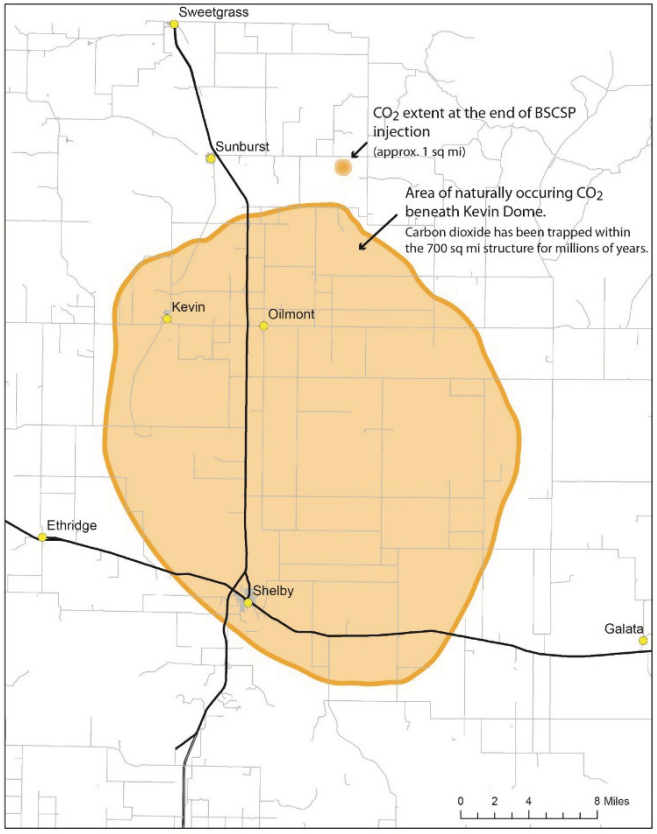
- **Seal impermeability**
- **Seal continuity**
- Seal thickness
- Geochemistry
- Mechanical Properties

Domes Are Attractive Early Storage Target



Half of the current major point source emissions for the next 100 years **~7.5 GT**

Resource Estimate for 3 Domes **~5.3 GT**



- Prevent trespass issues – buoyancy flow will take CO_2 to top of dome
- Potential use as carbon warehouse – decouple anthropogenic CO_2 rate from utilization rate

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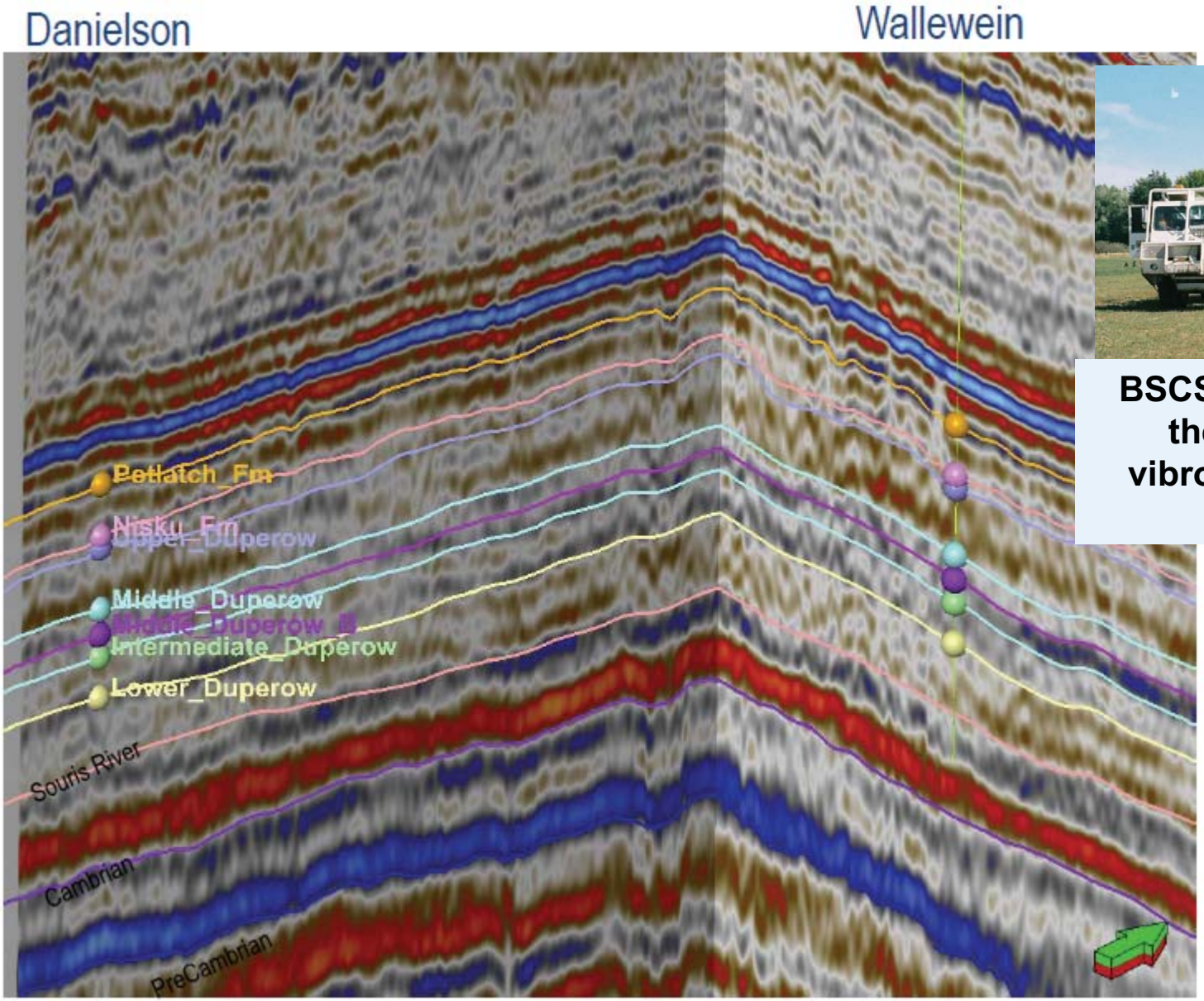
Site Characterization - 3D Seismic

Vecta Oil & Gas Ltd.



BSCSP Partner, Vecta has the only shear wave vibroseis trucks in North America.

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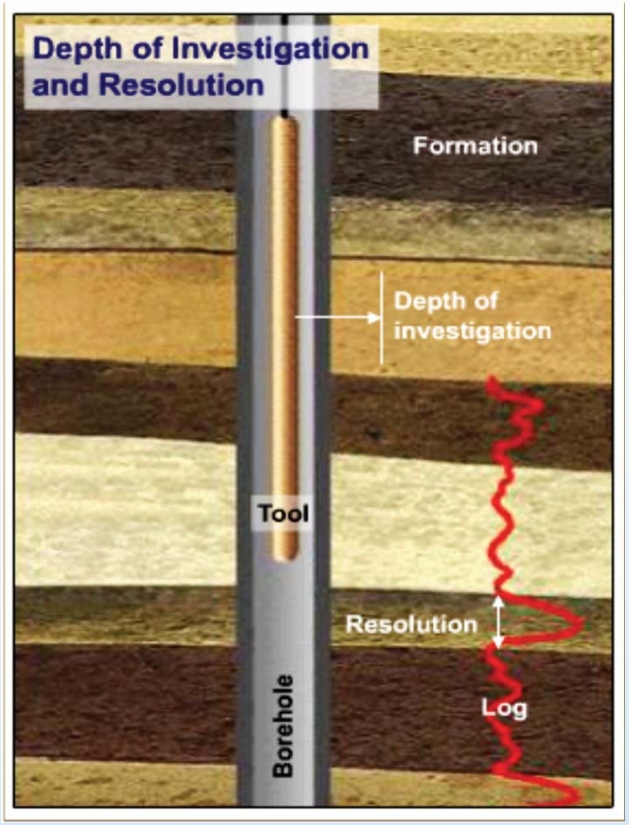
Well Drilling, Log and Core Data

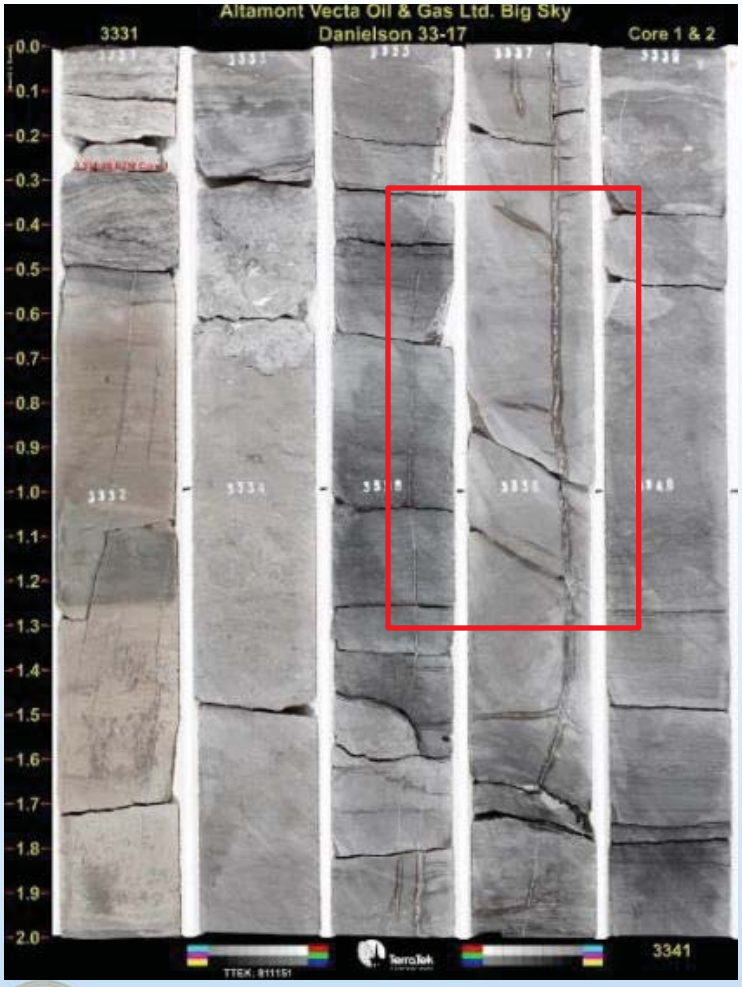
Geophysical Characterization & Monitoring: Well Logging



Logs	Wells			
	1st Prod	Inj	Mon	All
Downhole P & T	Cont.	Cont.	Cont.	Cont.
Gamma Ray	Init	Init	Init	Init
Resistivity	Init	Init	Init	Init
Porosity	Init	Init	Init	Init
Density	Init	Init	Init	Init
Caliper	Init	Init	Init	Init
P&S Sonic	Init	Init	Init	Init
Sonic Scanner	Init	Init	Init	
Isolation Scan	Init	Init	Init	
FMI	Init	Init	Init	
NMR	Init	Init	Init	
Natural Gamma	Init	Init	Init	
Elemental Spec	Init	Init	Init	
Cement Eval	Init	Init	Init	Init
Pulsed Neutron	Init	Annual	Annual/ 2 Annual	Init

Middle Duperow – Fractures

Site Characterization: Core Fracture Analysis



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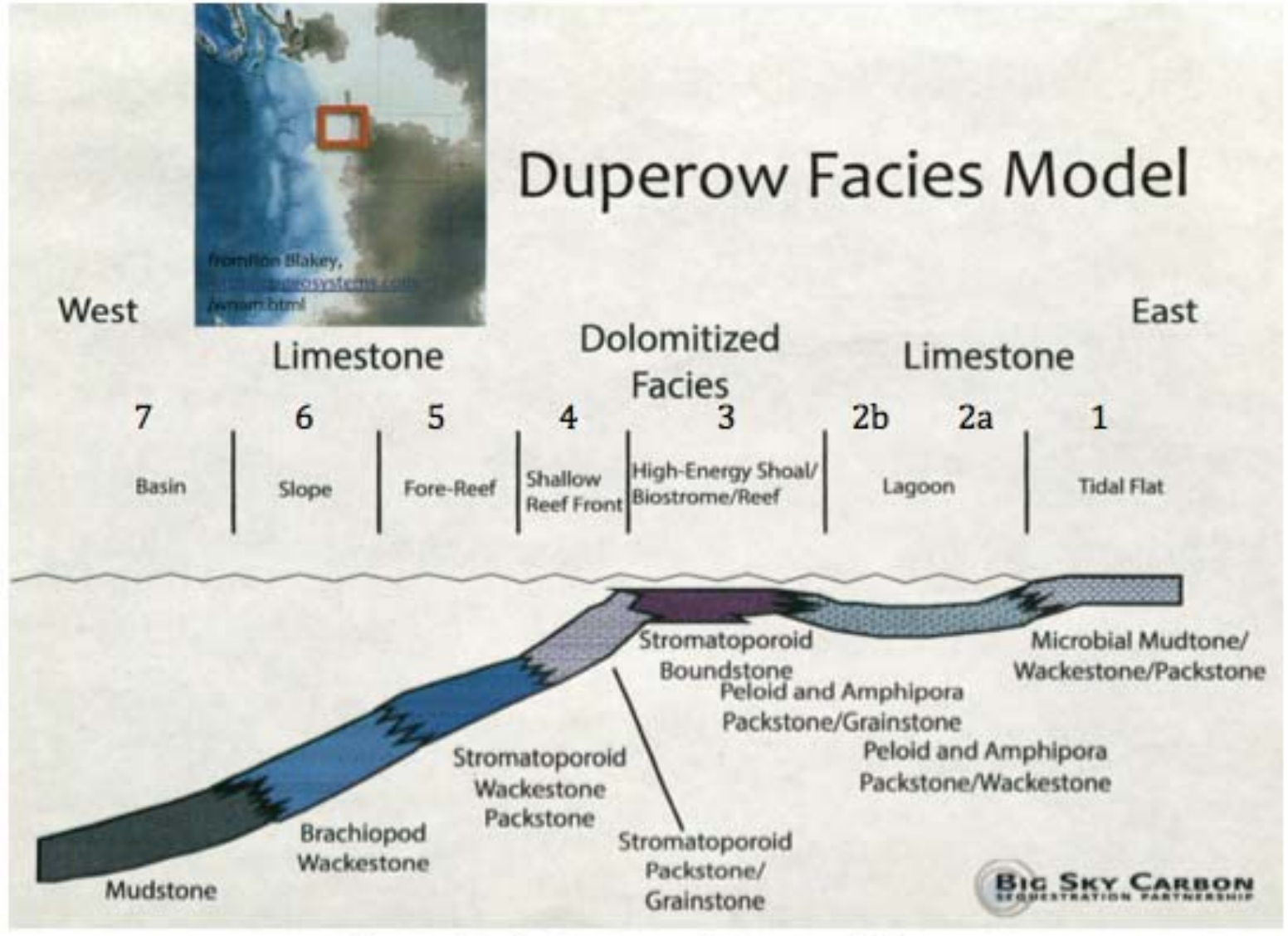
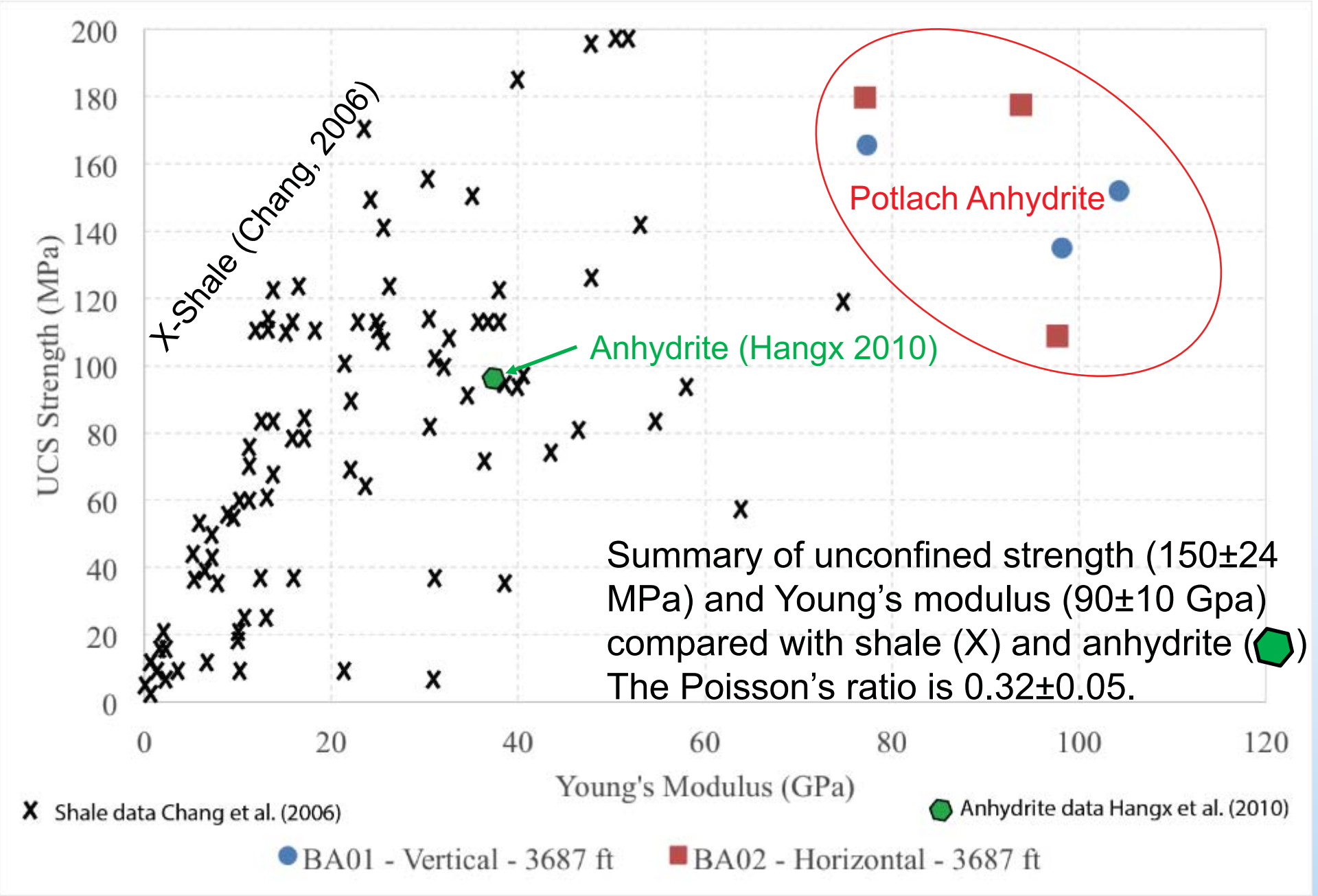
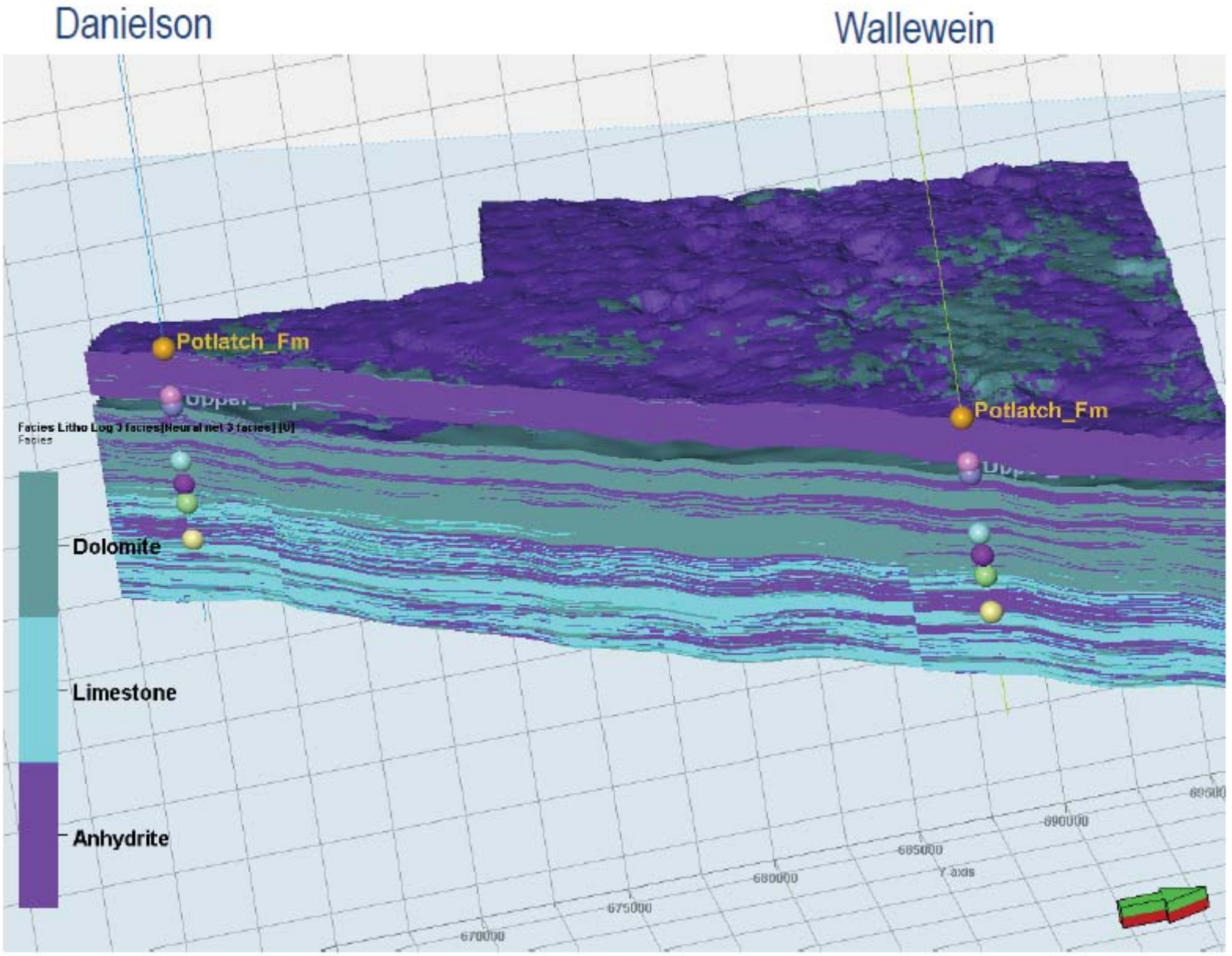
Fracture Analysis of Cored Intervals of the Duperow



Caprock Geomechanical Tests

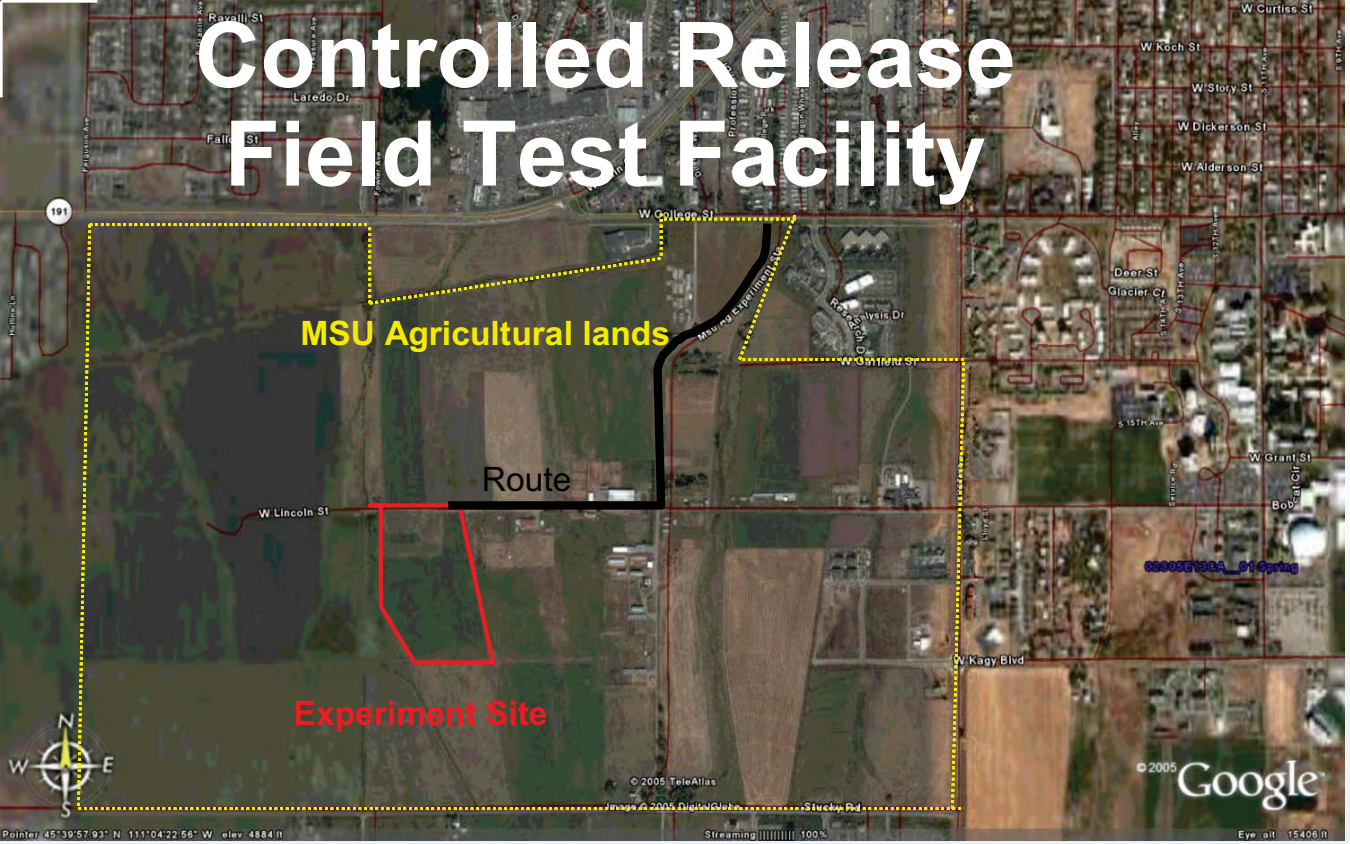


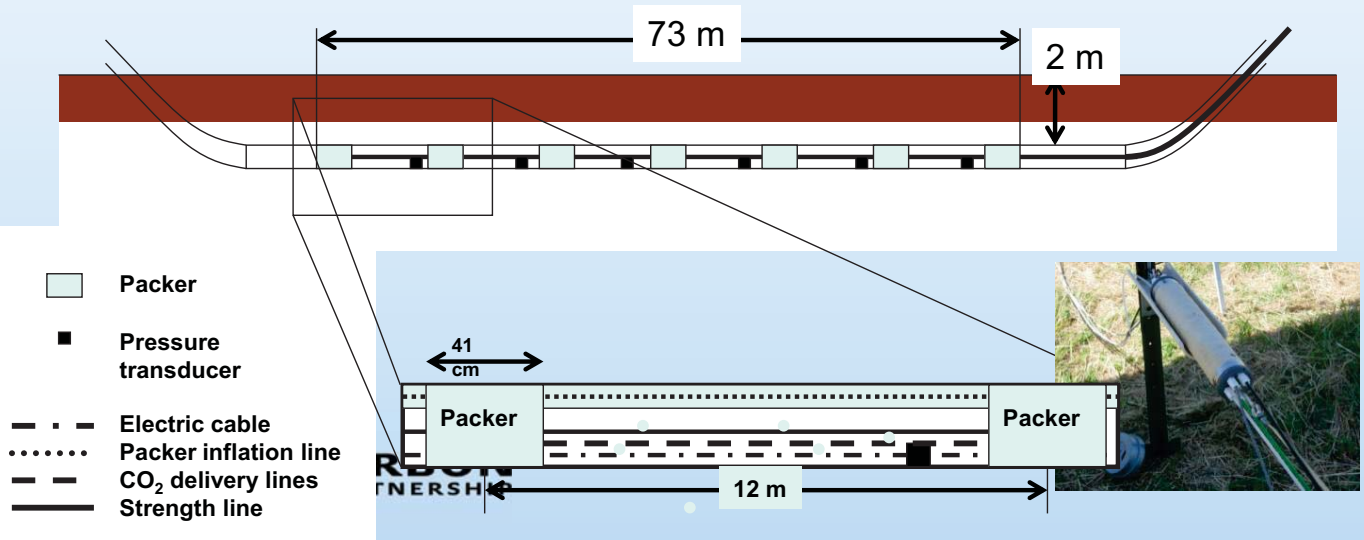
Modeling


Danielson
Wallewein
Potlatch_Fm
Potlatch_Fm
Facies Litho Log 3 facies|Neural net 3 facies] [U]
Facies
Dolomite
Limestone
Anhydrite
690000
685000
680000
675000
670000
Y axis

ZERT Controlled Release Facility

Controlled Release Field Test Facility





Site to test near surface detection technologies (first in the world)

>100 Investigators
41 Sensors
7 Universities
8 Gov. Labs,
7 Companies

Consulted / Imteracted on facilities on 4 continents in Brazil, Denmark, Norway, UK, Australia, Korean

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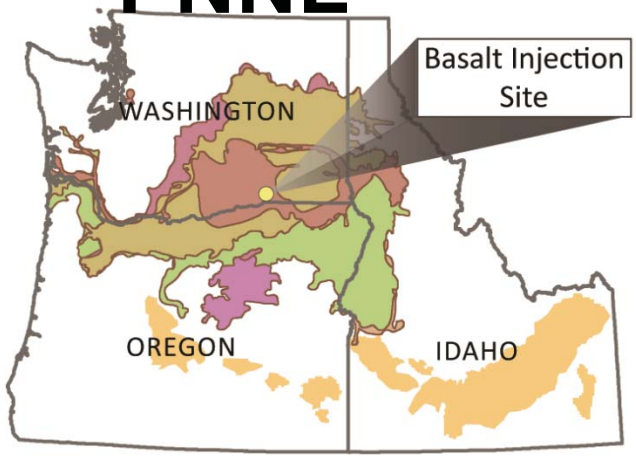
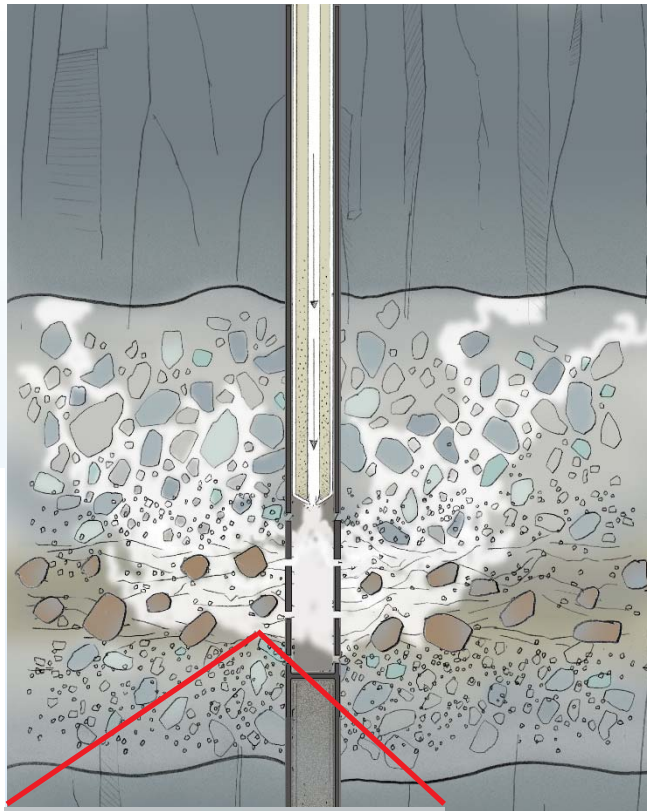
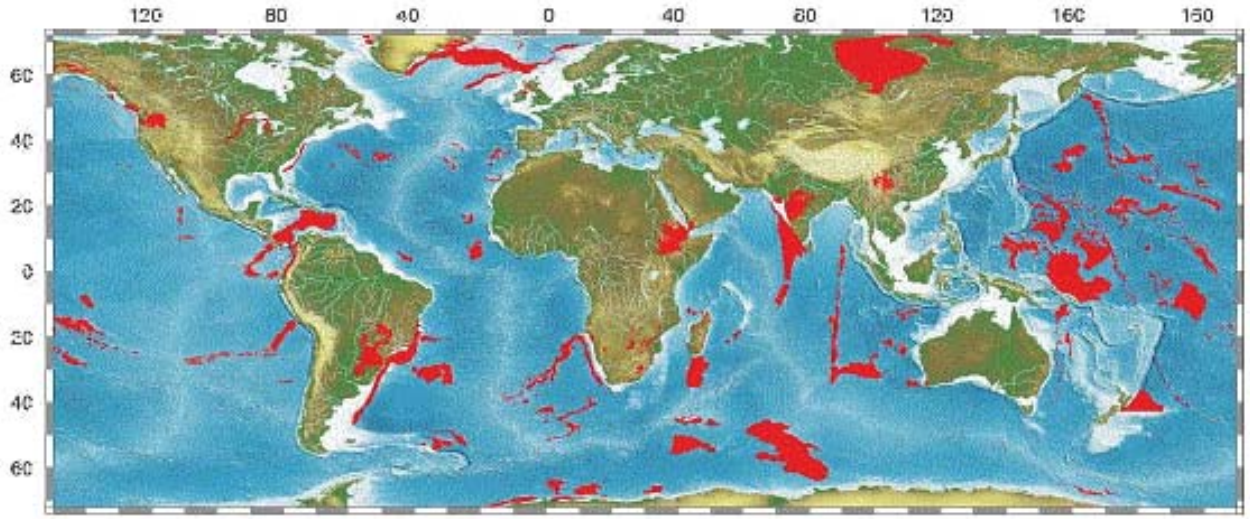
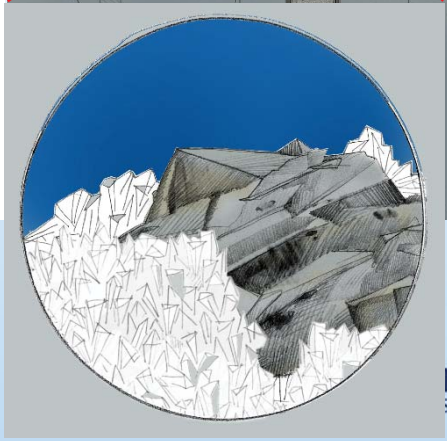
Basalt Storage

PNNL







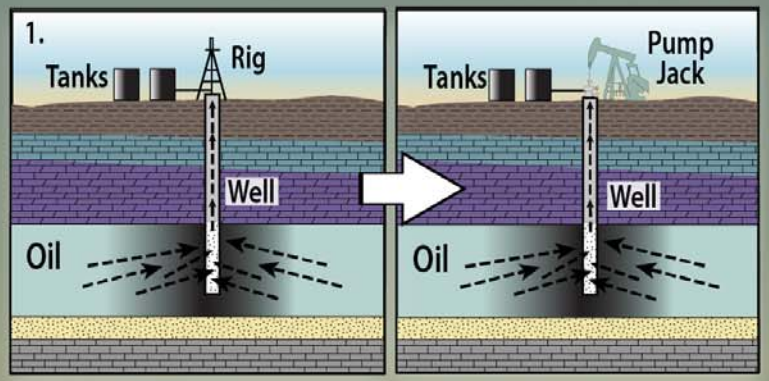


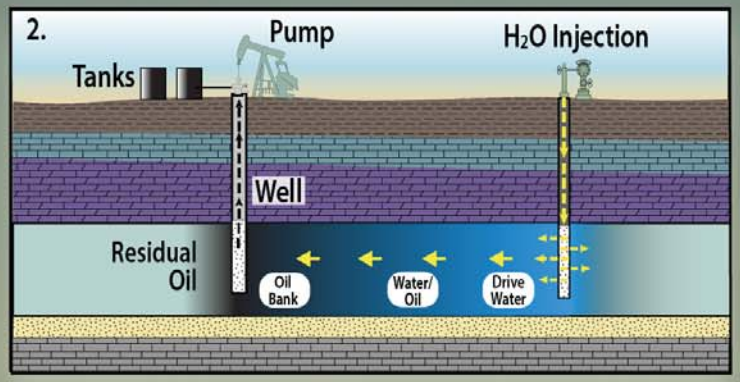
Oil Field Lifecycle and the Use of CO_2-EOR

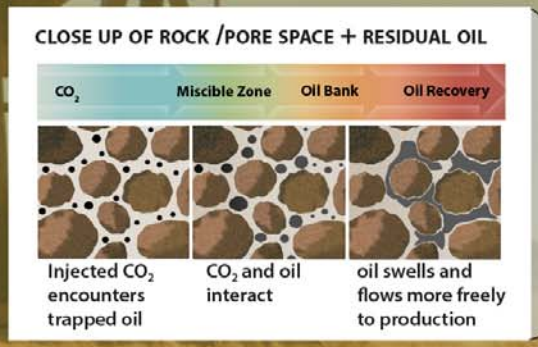
1 Primary — Primary production uses formation pressure followed by pumps to draw oil to the surface through the well bore

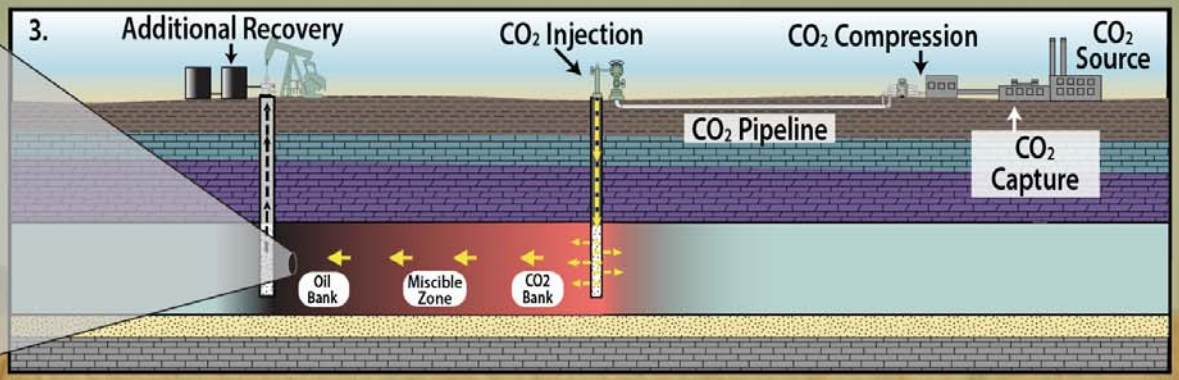
2 Secondary — Secondary recovery includes pumping water into the reservoir to push out residual oil

3 Tertiary — When conditions are right, injected CO_2 acts like a "degreaser" and can mobilize residual oil to the surface

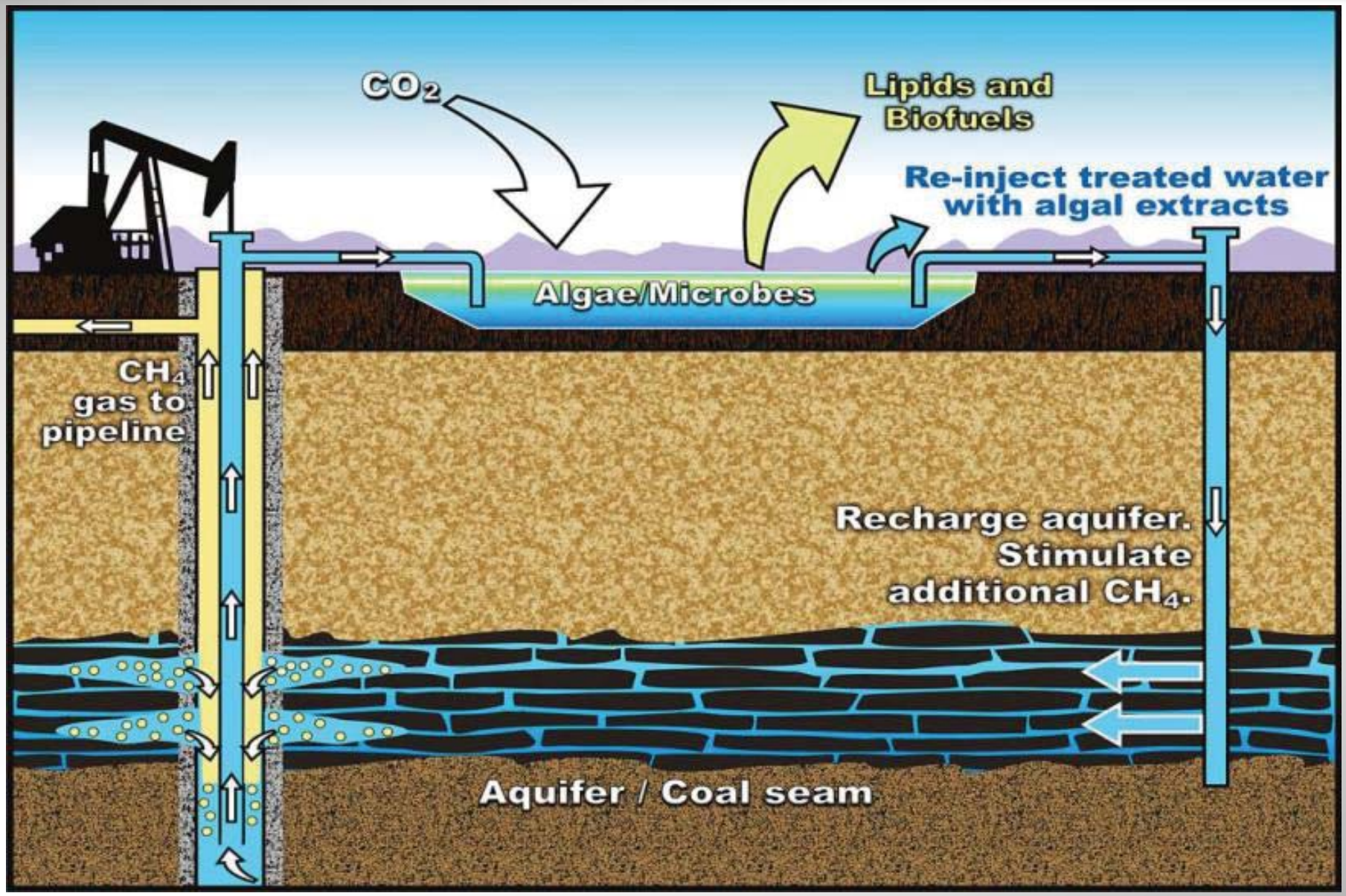






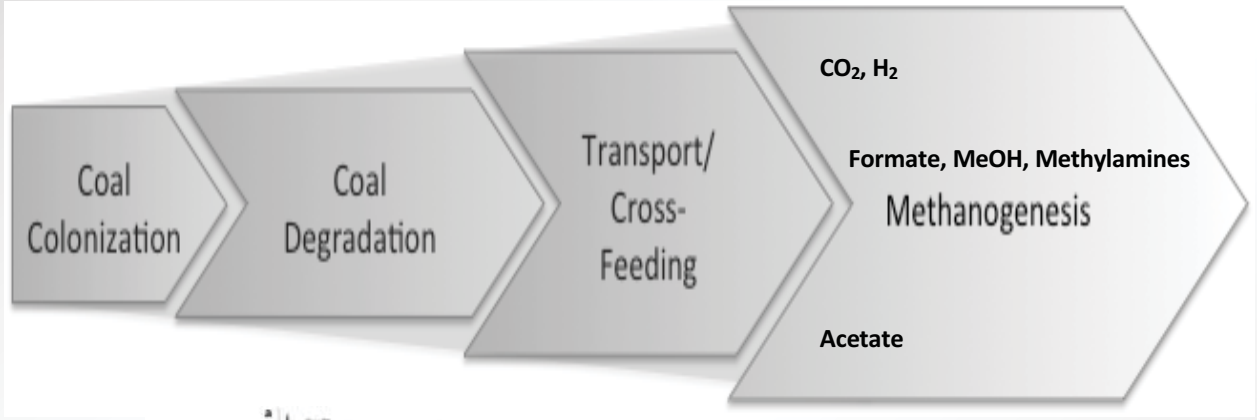


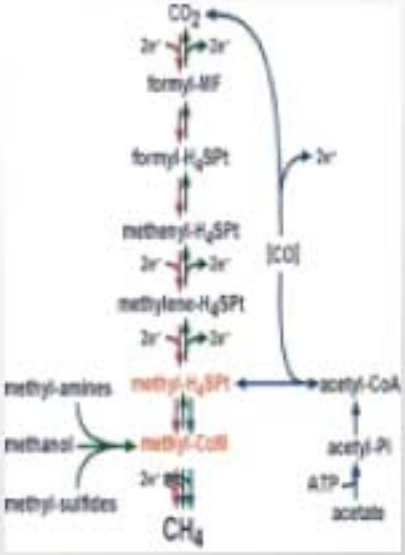
Microbially Enhanced Coal Bed Methane Concept



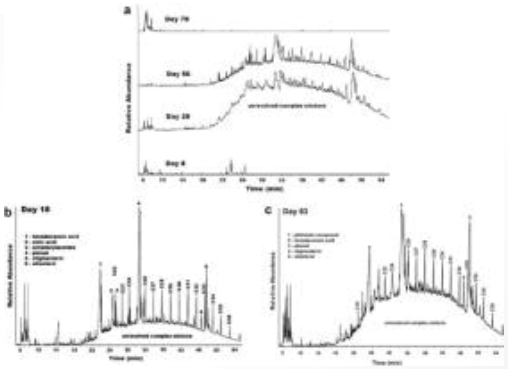
Coal→ Natural Gas (CH_4)

Activity: Coal-dependent growth & conversion
Thermodynamics: Conditions that promote growth & conversion
Reactive Transport: Movement of Nutrients/Organisms/Cross-Feeding



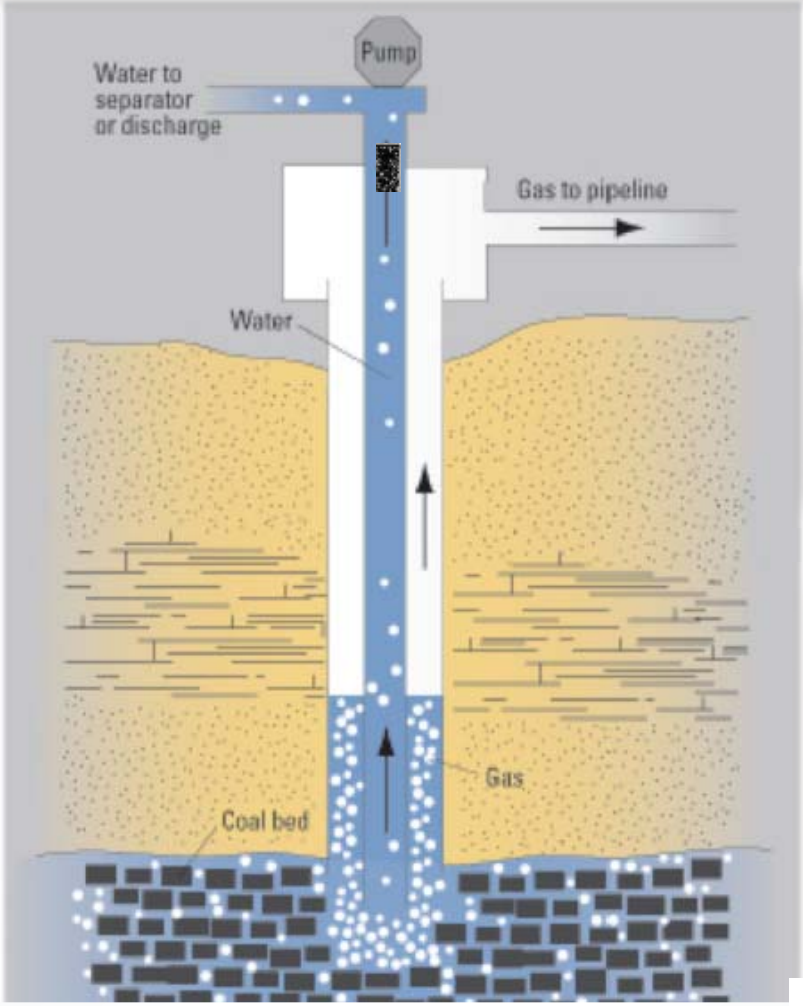


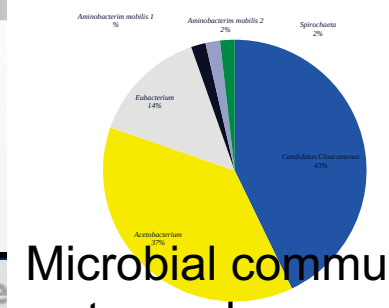
Metabolites

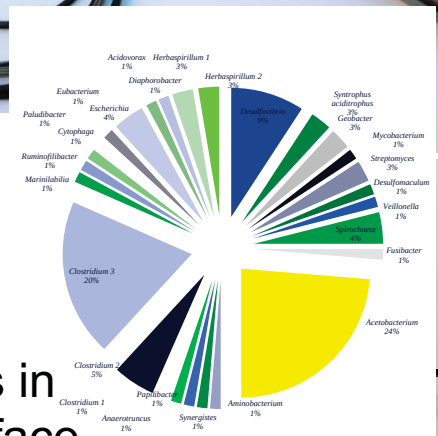


Orem, W. et al., 2010. *Organic Geochem.*

Sampling: Water vs. Coal Matrix

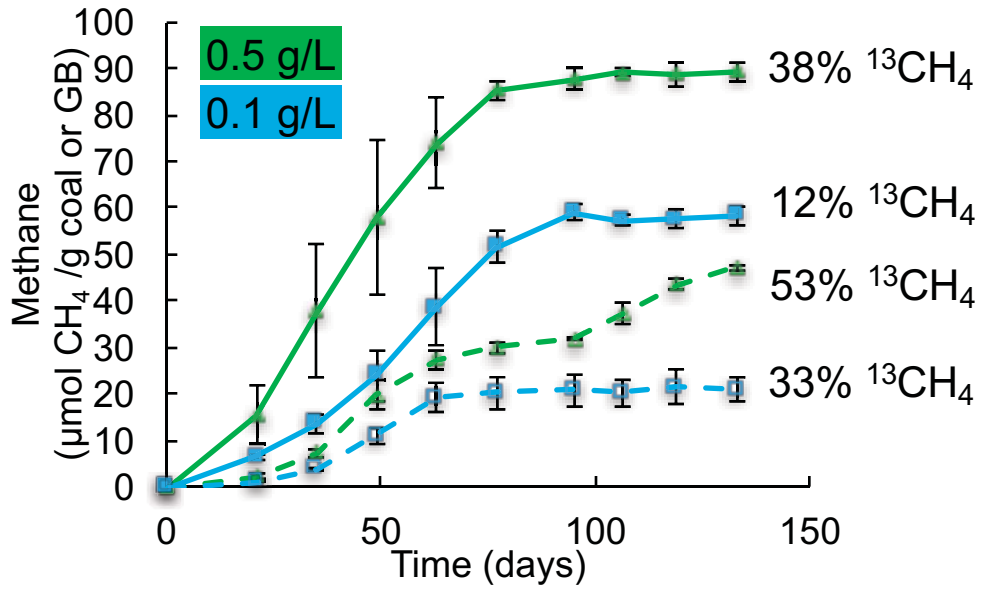






Microbial communities in water and on coal surface

^{13}C-algae amendment indicates CH_4 carbon source



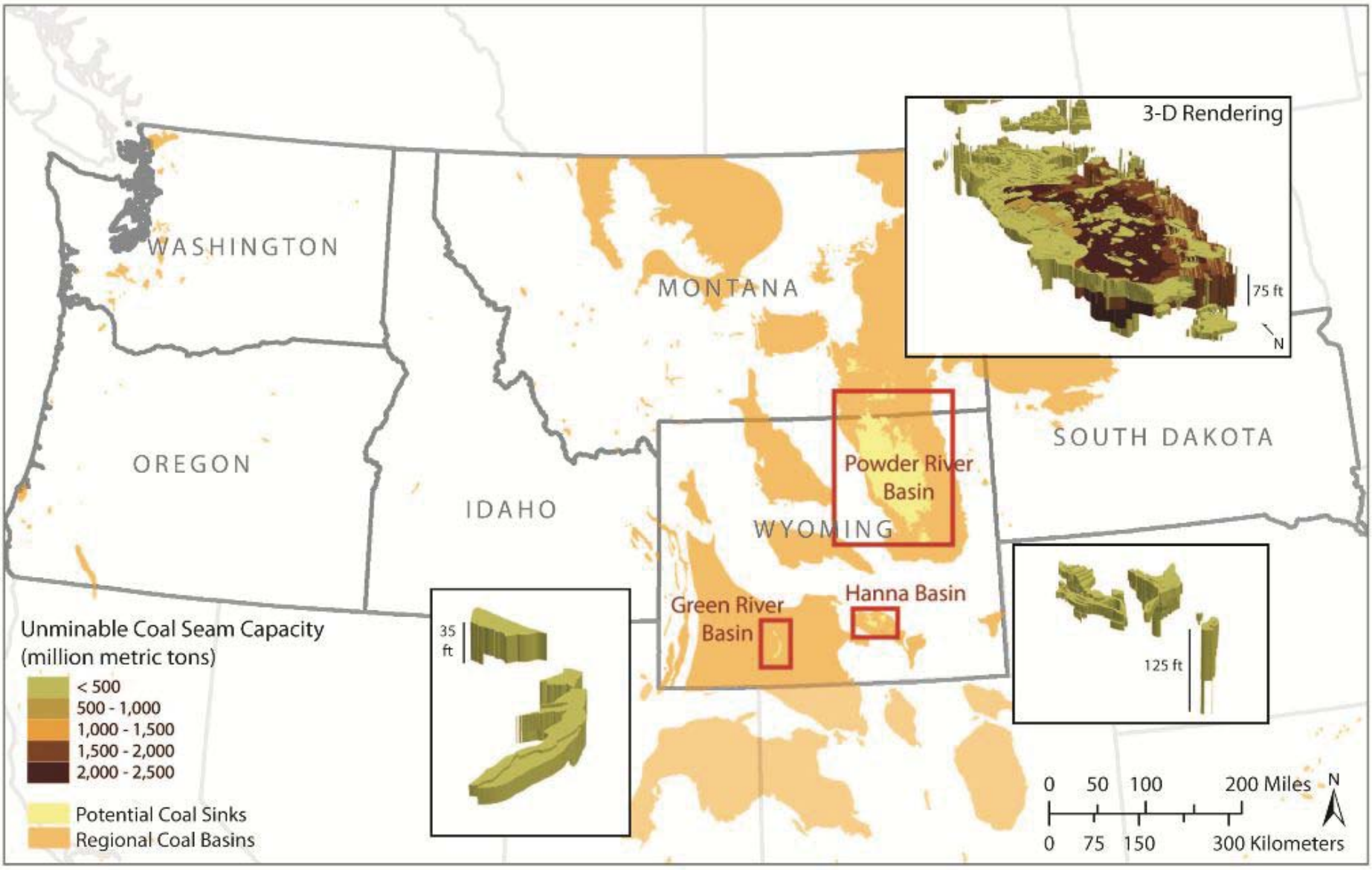
GB = Glass Beads Used for control
Dashed lines in graph

Treatment	% amendment converted to $^{13}CH_4$
0.1 g/L 13-algae + coal	15.3 ± 0.7
0.1 g/L 13-algae + GB	15.7 ± 1.6
0.5 g/L 13-algae + coal	15.4 ± 0.8
0.5 g/L 13algae + GB	11.5 ± 0.0

Treatment	$^{13}CH_4$ (µmol/g coal)	$^{12}CH_4$ (µmol/g coal)
0.1 g/L 13-algae + coal	6.3 ± 0.3	52.1 ± 2.0
0.1 g/L 13-algae + GB	6.4 ± 0.6	14.4 ± 2.1
0.5 g/L 13-algae + coal	31.6 ± 1.6	57.8 ± 0.7
0.5 g/L 13-algae + GB	23.7 ± 0.1	23.5 ± 0.6

x5

x5



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