Experimental studies using supercritical CO_2 to challenge brine aquifer rocks

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Outline

- Introduction
- Previous studies
- Experimental plan
- Field study
- Summary
- Future work

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Introduction

- Anthropogenic CO_2 emissions likely contribute to climate change (IPCC 2007)

- Geologic sequestration offers potential to reduce future atmospheric CO_2 emissions

- Suggested targets for geologic sequestration of CO_2
  - Depleted oil and gas reservoirs
  - Deep unmineable coal seams
  - **Deep brine aquifers**

Deep brine aquifers

- CO_2 storage in deep brine aquifers viewed as a promising option
  - Large potential storage volume
  - Widespread across US
  - CO_2 injection technology available now

- Study goals
  - Develop experimental apparatus to simulate subsurface gas-water-rock interactions using rock cores from outcrop
  - Evaluate physical and chemical changes in Madison Formation cores, Powder River Basin in response to CO_2 flooding in laboratory experiments

Previous laboratory CO_2 flooding studies

- Shiraki and Dunn (2000) - Tensleep sandstone
- O'Connor and Dahlin (2001, 2002) - Berea sandstone
- Kaszuba et al. (2003) - synthetic arkose in batch reactor
- Wolf et al. (2004) – serpentine in static reactor

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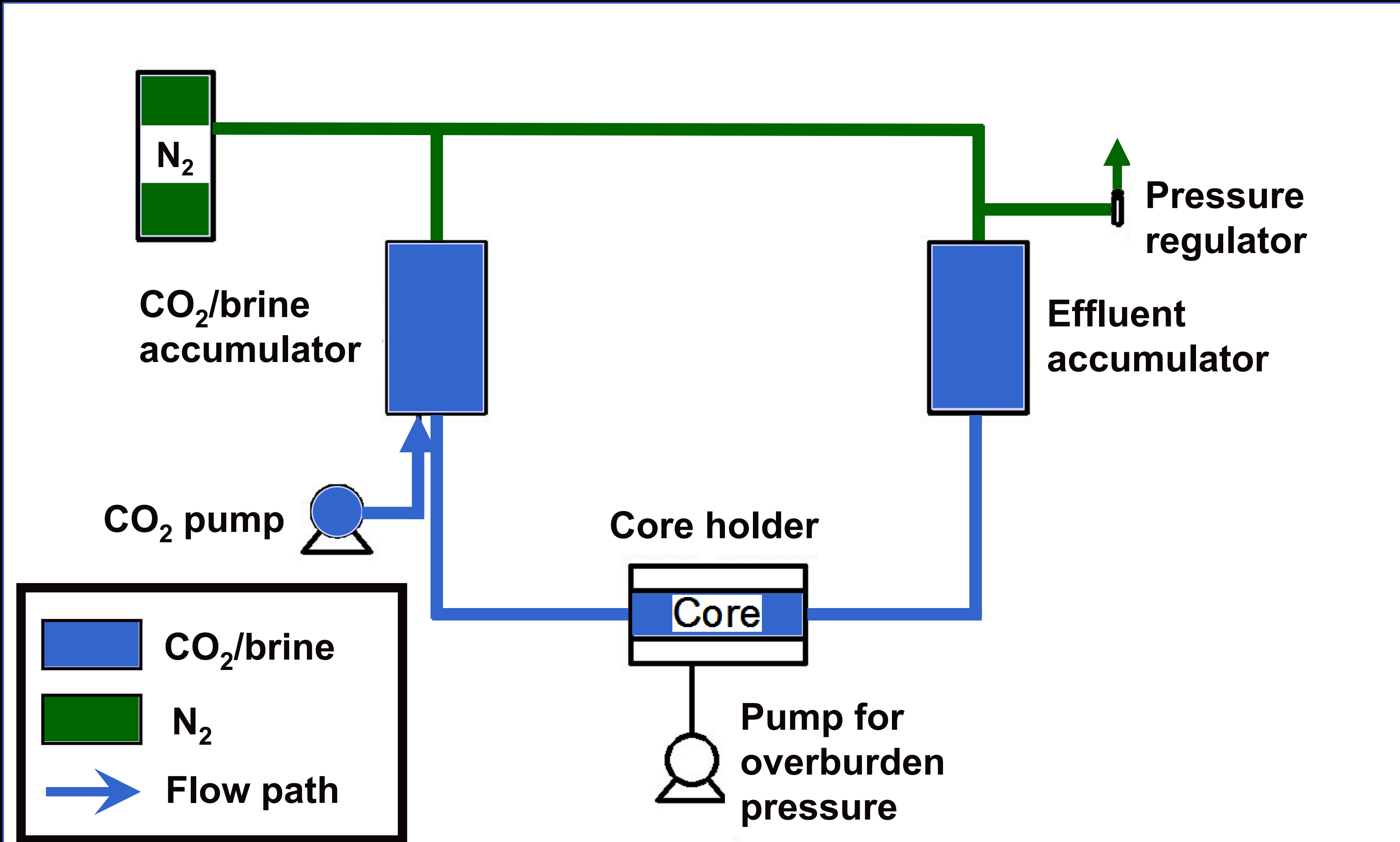
Experimental goal

- Develop flow-through reactor
  - Simulate subsurface conditions, i.e. temperature, pressure
  - Test 1” x 6” rock cores
  - Variable flow rate and duration
- Initial testing conditions
  - 1500 psi, 55°C, 5 day flood
  - Floods conducted with and without reproduced formation water
- Evaluate physical and chemical effects

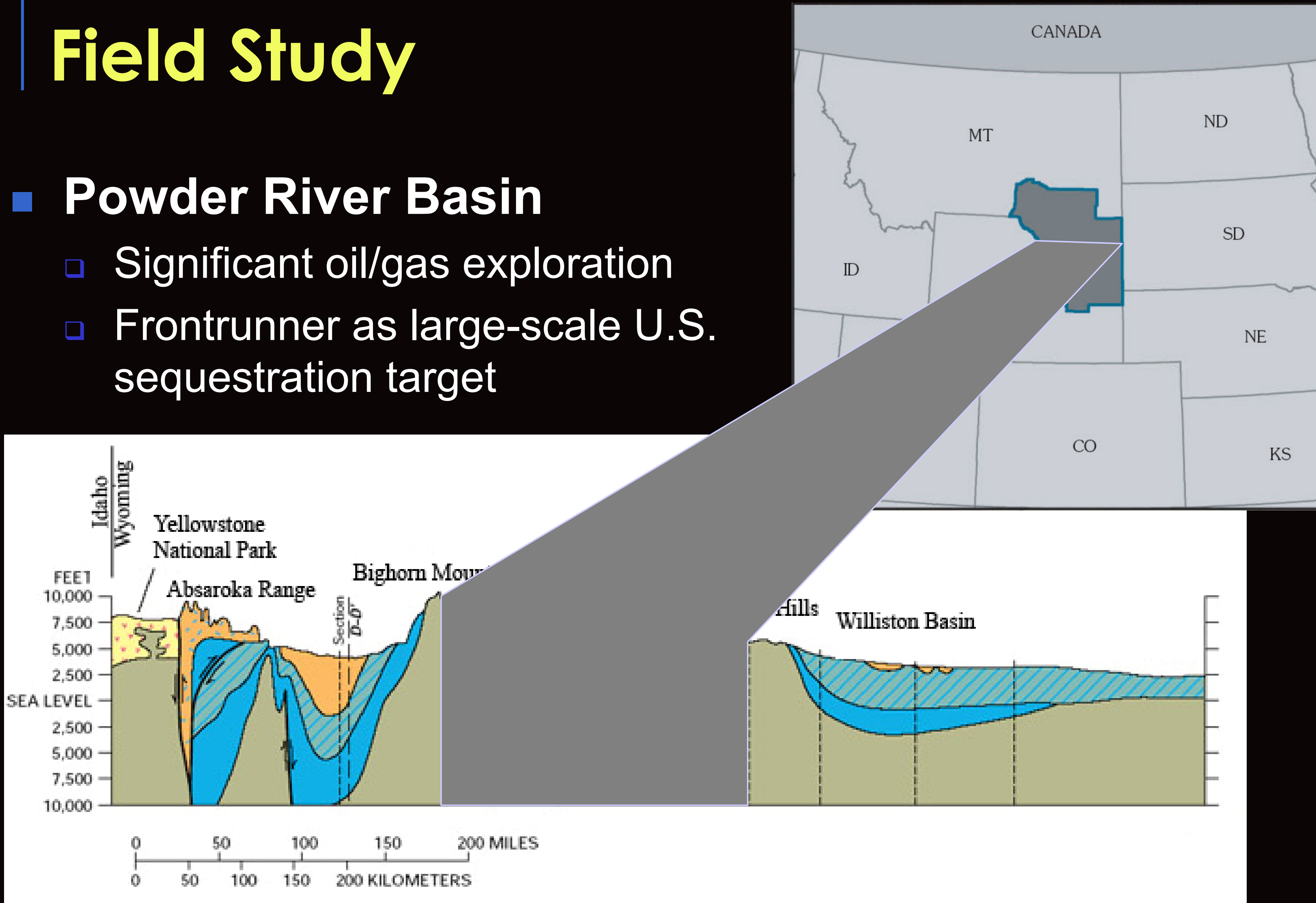
Flow reactor system



Flow reactor system

Field Study

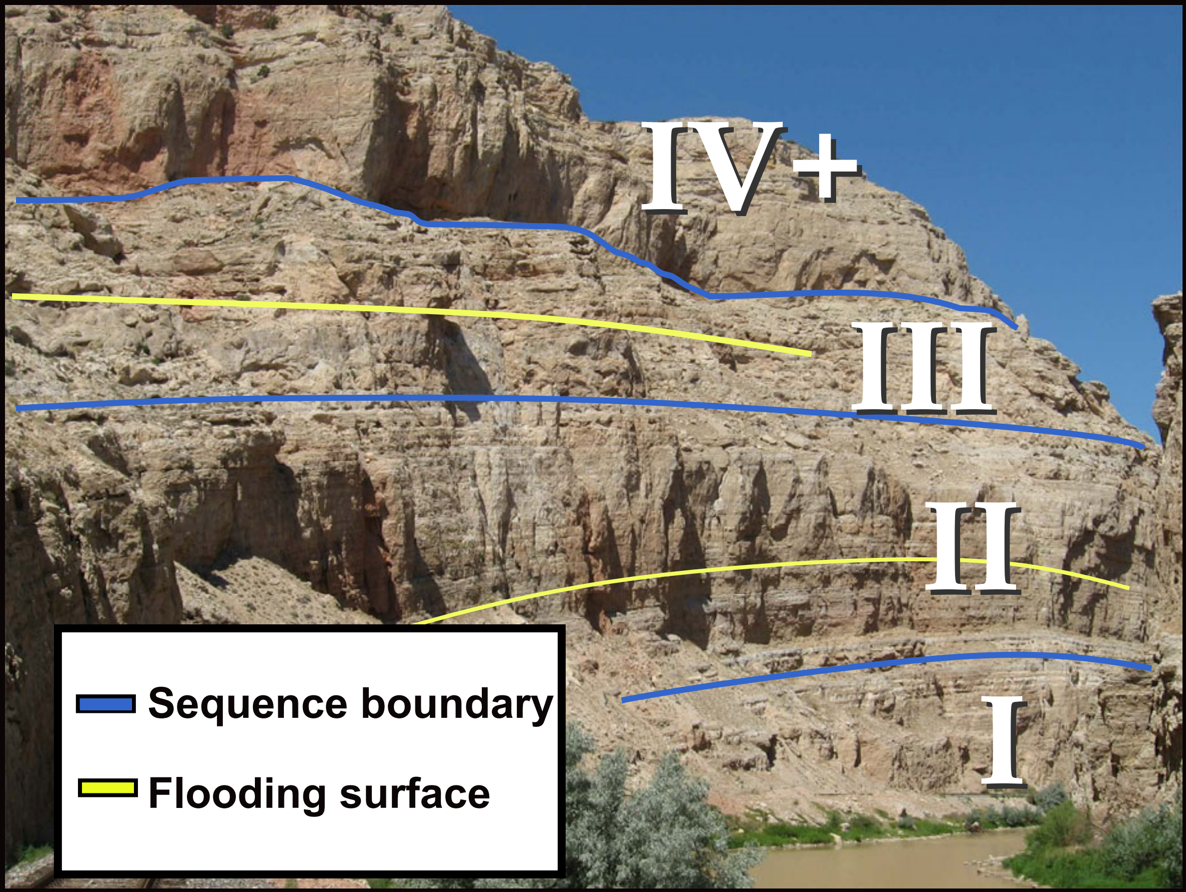
- **Powder River Basin**
  - Significant oil/gas exploration
  - Frontrunner as large-scale U.S. sequestration target



(AAPG, 1974; USGS, 2004)

Madison Formation

- Limestone and dolostone
- Up to 800 ft. thick in PRB
- May be able to store 60 Gt CO_2 ?
  (Fischer et al., 2005)



(Sonnenfeld, 1996)

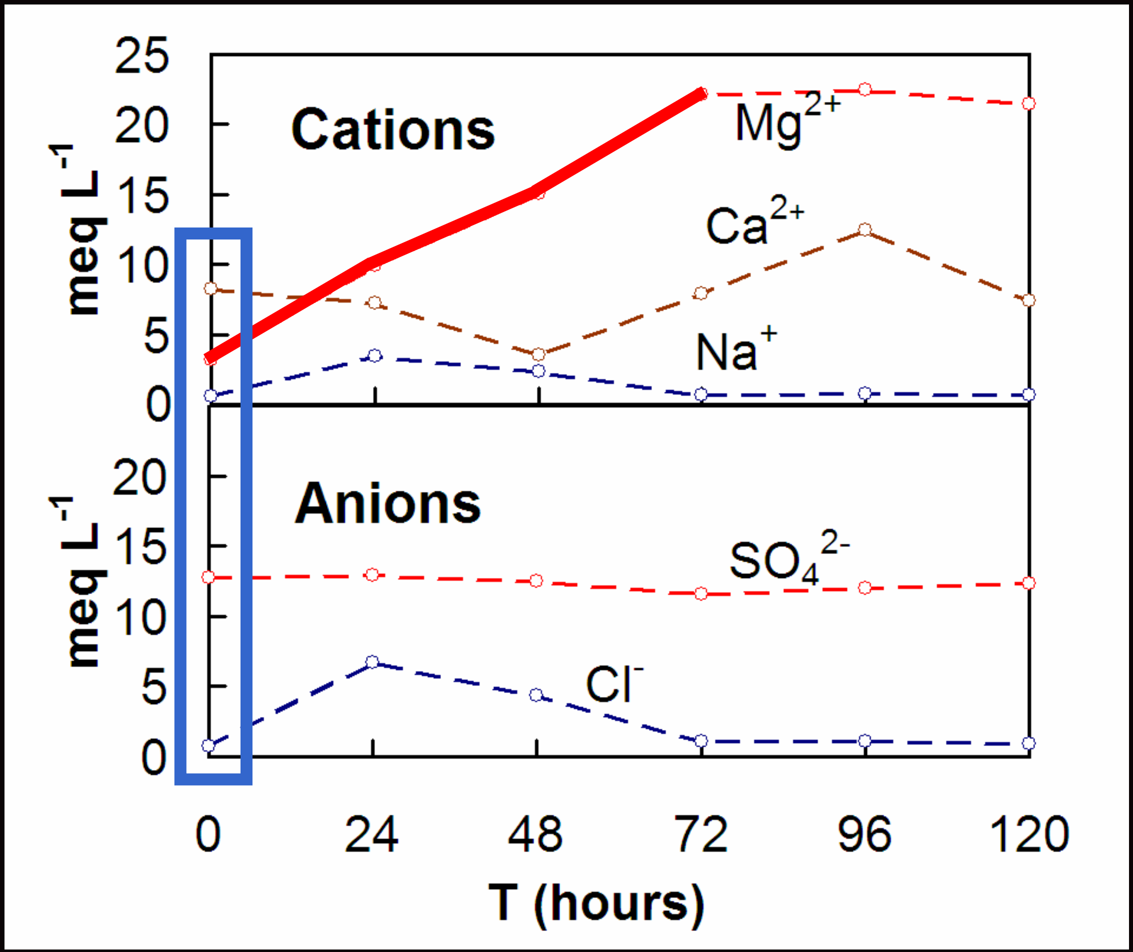
Analysis

- Mercury injection porosity
- Air permeability
- Liquid permeability
- Crush strength
- Ion chromatography on brine

Physical results

Sample	Porosity	Liquid Permeability (mD)	Air Permeability (mD)	Unconfined Fracture Strength (psi)
CONTROL	0.130	23	29	5460
DRY	0.156	24	30	5535
BRINE	0.141	43	52	4780

Chemical results



- Increase in $Mg^{2+}_{(aq)}$ for first 3 days
- $HCO_3^-{}_{(aq)}$ likely counterion for Mg2+(aq)

Summary

- Core challenges without brine produced little measurable change
- Challenges with reproduced formation water produced measurable changes
  - Increased $Mg^{2+}_{(aq)}$ from dolomite dissolution
  - Decreased unconfined fracture strength
  - Permeability increase with minor porosity increase

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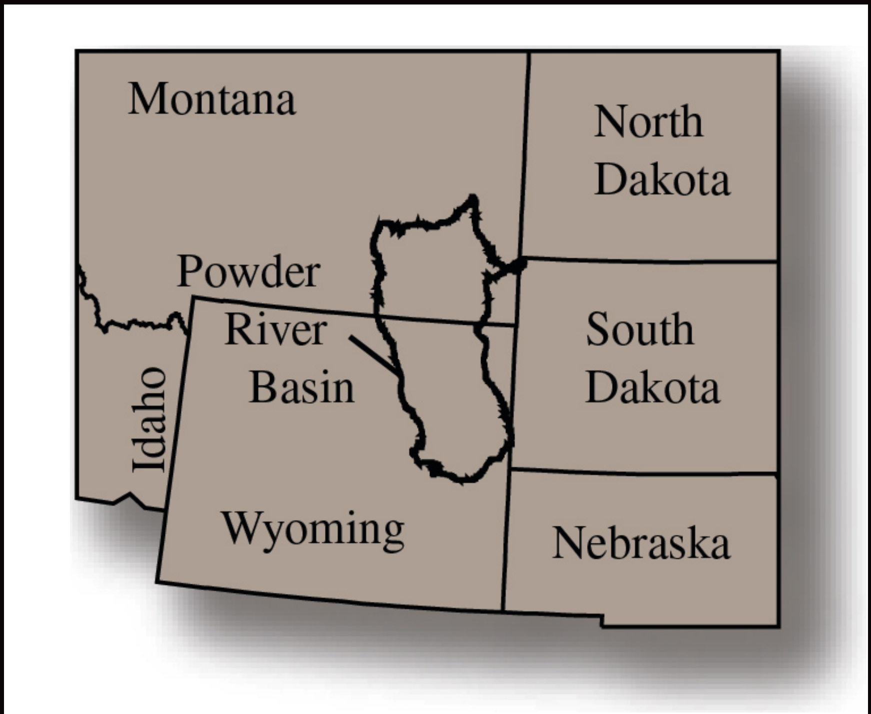
Applicability

- Develop robust testing apparatus for range of gas-water-rock interactions
- Provide data for modeling studies on brine aquifer systems

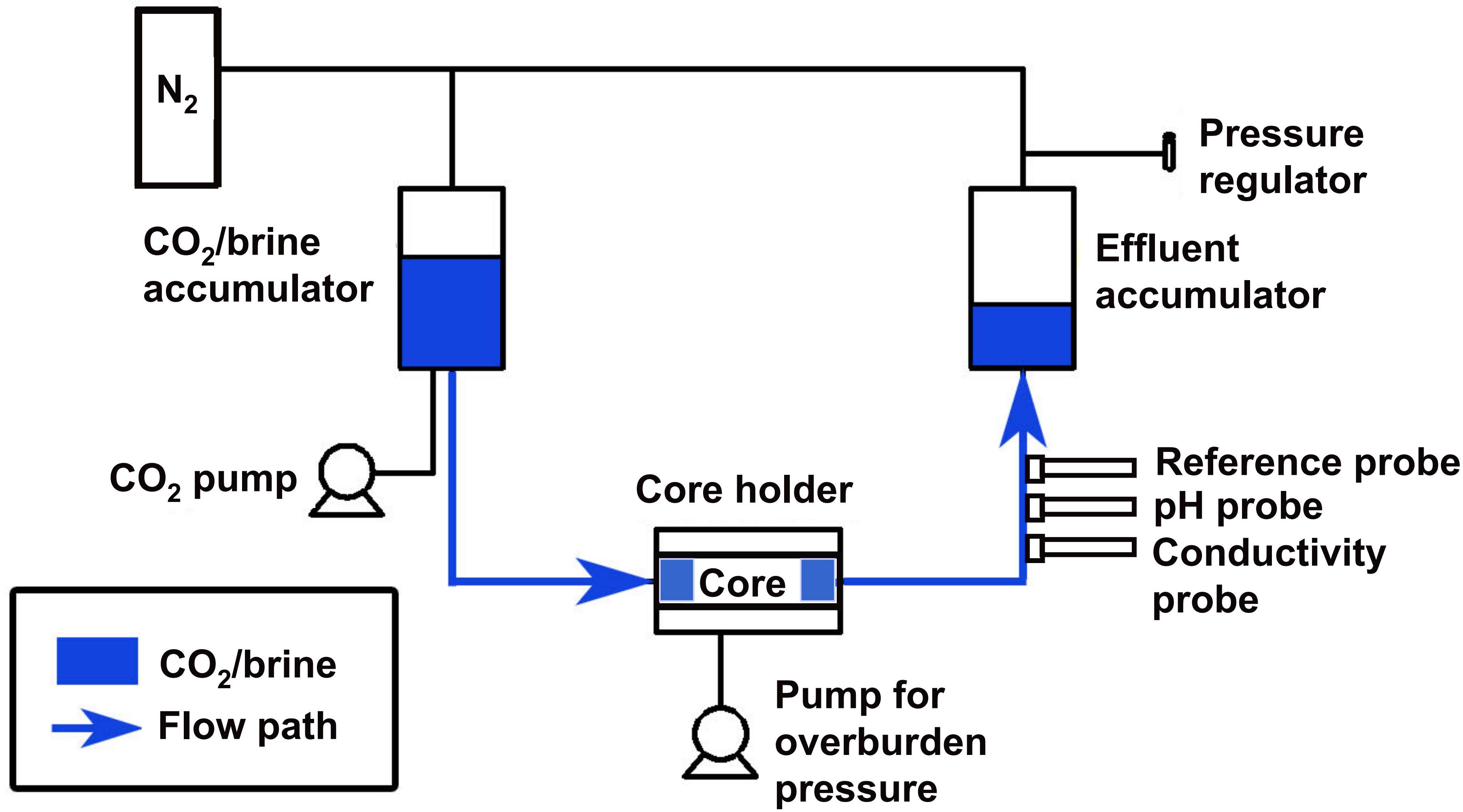


USGS (2004)

Future work

- Increase temperature range up to 95°C
- Test additional brine concentrations
- Longer duration floods
- Equipment upgrades
  - Additional 24 hour real-time monitoring (pH, conductivity, differential pressure)

Future work



N_2
Pressure regulator
CO_2/brine accumulator
Effluent accumulator
CO_2 pump
Reference probe
pH probe
Conductivity probe
Core holder
Core
CO_2/brine
Flow path
Pump for overburden pressure

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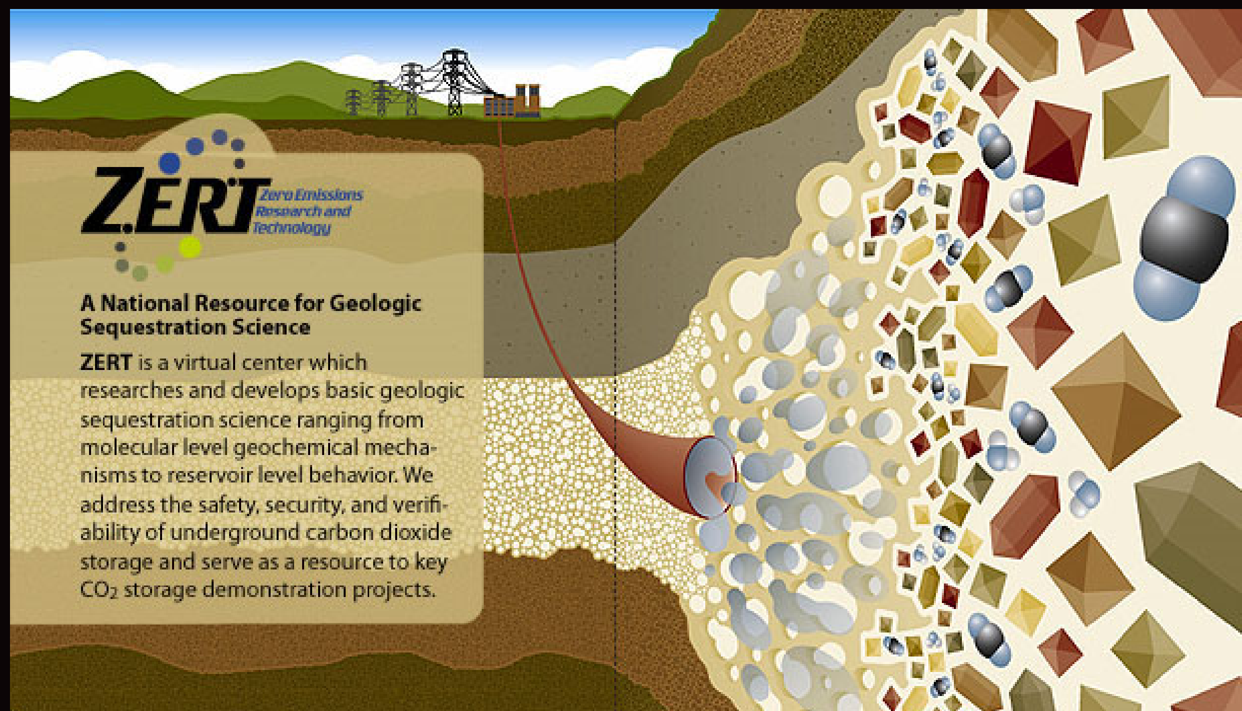

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