



A New Energy Future for Montana, Idaho, South Dakota, Wyoming, the Pacific Northwest and the Nation

Big Sky Carbon Sequestration Partnership: Evaluating Potential Sequestration

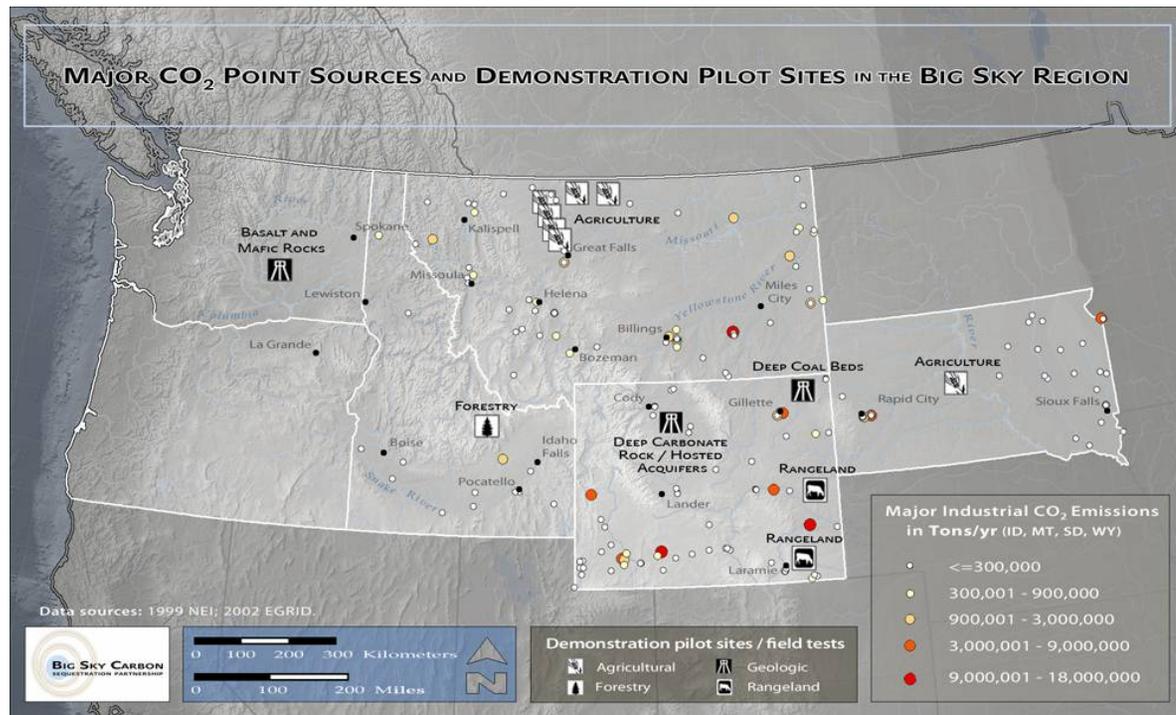
Susan M. Capalbo
Robert Smith

Fifth Annual Conference on Carbon Capture & Sequestration
May 11, 2006



Big Sky Carbon Sequestration Partnership

- One of seven DOE funded partnerships focused on validating the most promising regional opportunities to deploy sequestration technologies



Composition of Partnership

- Research Institutions (universities, labs, others)
 - including MSU, SDSMT, UI, UWYO, ISU, BSU, PNWD, LANL, INL, Columbia U
- State, federal agencies (includes USDA, USGS, NASA)
- Industry members including major power producers
- Carbon trading entities (NCOC)
- Outreach Education partners, including Governors' office in WY, MT, WA
- Tribal Nations and Councils
- International Collaborators (includes Canada, Norway, India)

Partners

BATTELLE PACIFIC NORTHWEST DIVISION
BOISE STATE UNIVERSITY
BULLIVANT HOUSER BAILEY PC
CENTER FOR ADVANCED ENERGY STUDIES AT INL
CENTER FOR ENERGY & ECONOMIC DEVELOPMENT
CLEAN ENERGY SYSTEMS
COLUMBIA UNIVERSITY, LAMONT-DOHERTY EARTH OBSERVATORY
DET KONGELIGE OLGE - OG ENERGIDEPARTEMENT
ENERGY NORTHWEST
ENTECH STRATEGIES, LLC
IBM
IDAHO CARBON SEQUESTRATION ADVISORY COMMITTEE
IDAHO DEPARTMENT OF ADMINISTRATION
IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY
IDAHO NATIONAL LABORATORY
IDAHO SOIL CONSERVATION COMMISSION
IDAHO STATE UNIVERSITY
INLAND NORTHWEST RESEARCH ALLIANCE
INSTITUTE FOR ENERGY TECHNOLOGY (NORWAY)
INSTITUTE DE PHYSIQUE DU GLOBE DE PARIS (FRANCE)
INTERTRIBAL TIMBER COUNCIL
JACKSON HOLE CENTER FOR GLOBAL AFFAIRS
LOS ALAMOS NATIONAL LABORATORY
MONTANA BUREAU OF MINES AND GEOLOGY
MONTANA DEPARTMENT OF AGRICULTURE
MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY
MONTANA FARM BUREAU FEDERATION
MONTANA GEOGRAPHIC INFORMATION COUNCIL
MONTANA GOVERNOR'S OFFICE
MONTANA STATE UNIVERSITY
NATIONAL CARBON OFFSET COALITION

NATIONAL GEOPHYSICAL RESEARCH INSTITUTE (INDIA)
NATIONAL TRIBAL ENVIRONMENTAL COUNCIL
NEZ PERCE TRIBE
NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY
OREGON STATE UNIVERSITY
PORTLAND GENERAL ELECTRIC
POWER PROCUREMENT GROUP
PUGET SOUND ENERGY (PSE)
RAMGEN POWER SYSTEMS, INC.
RESEARCH COUNCIL OF NORWAY
RUCKELSHAUS INSTITUTE FOR ENVIRONMENT
& NATURAL RESOURCES (UNIVERSITY OF WYOMING)
RUSSIAN ACADEMY OF SCIENCES
SAMPSON GROUP
SEMIARID PRAIRIE AGRICULTURAL RESEARCH CENTER (CANADA)
SEMPRA GENERATION
SINTEF PETROLEUM RESEARCH (NORWAY)
SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY
UNIFIELD ENGINEERING
UNIVERSITY OF IDAHO
UNIVERSITY OF WYOMING
UNIVERSITY OF WYOMING ENHANCED OIL RECOVERY INSTITUTE
WAGENINGEN UNIVERSITY (THE NETHERLANDS)
WASHINGTON STATE GOVERNOR'S OFFICE
WESTERN GOVERNORS' ASSOCIATION
WYOMING CARBON SEQUESTRATION ADVISORY
COMMITTEE (UNIVERSITY OF WYOMING)
WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY
WYOMING STATE GOVERNOR'S OFFICE
YELLOWSTONE ECOLOGICAL RESEARCH CENTER

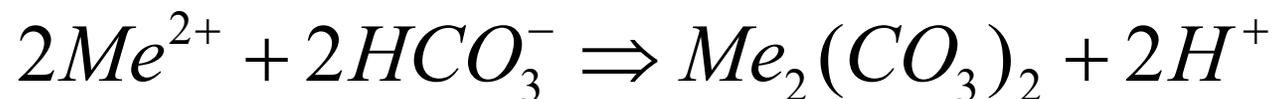
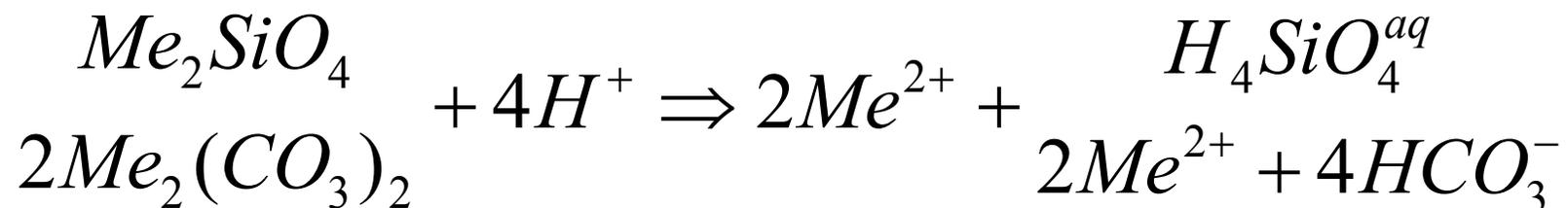
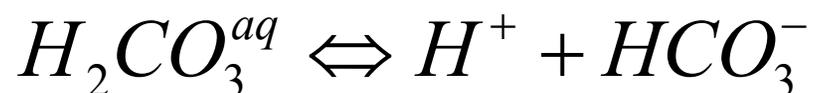
Organization of the Partnership

- Two focal areas
 - Geological sequestration opportunities
 - Terrestrial sequestration opportunities
- Five technical teams:
 - Carbon atlas/GIS
 - Geological pilots, including MMV
 - Terrestrial pilots, including MMV & carbon markets
 - Economic and risk analysis
 - Education, outreach, regulatory compliance issues

BSCSP Geologic Approach

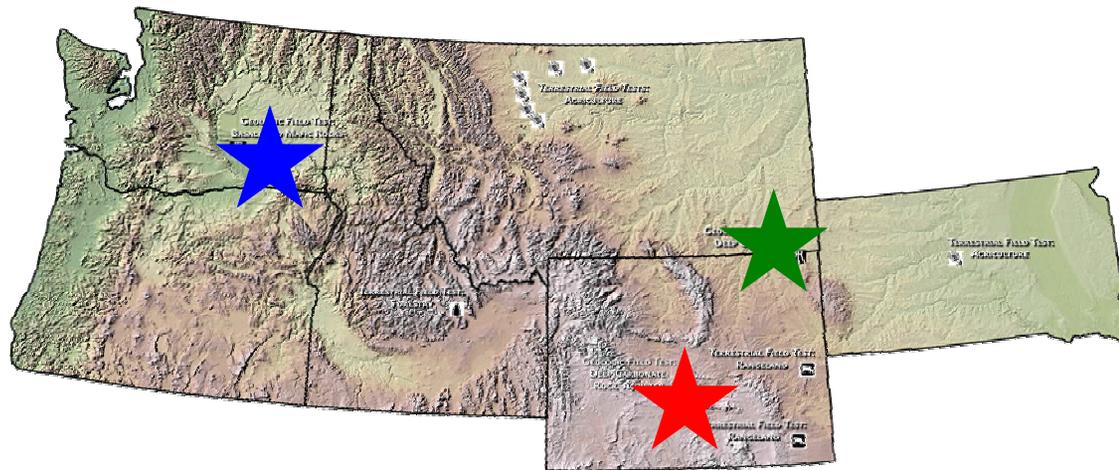
- Take advantage of reactive properties of CO₂
 - Identify sequestration targets with multiple trapping mechanisms
 - Emphasize mineral or other chemical reaction trapping
- Develop robust geologic sequestration options to permanently store CO₂
 - Sorption to regional abundant coal
 - Conversion to alkalinity and carbonate minerals

Reactive Trapping of CO₂



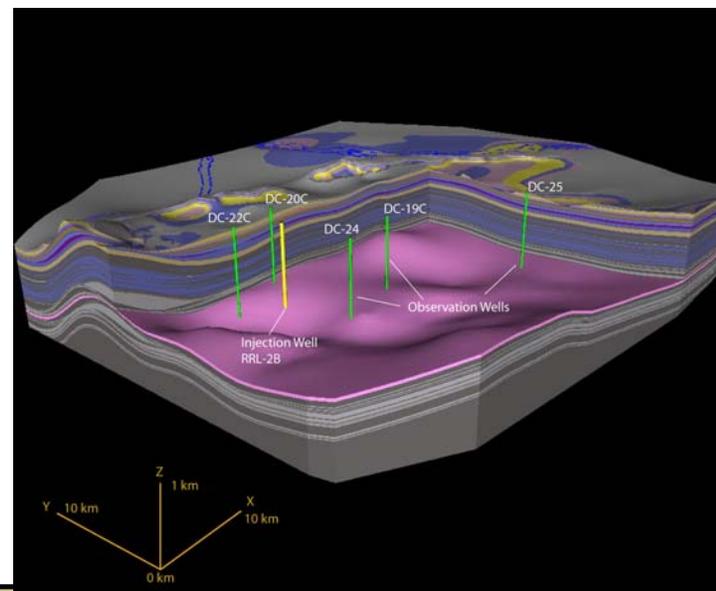
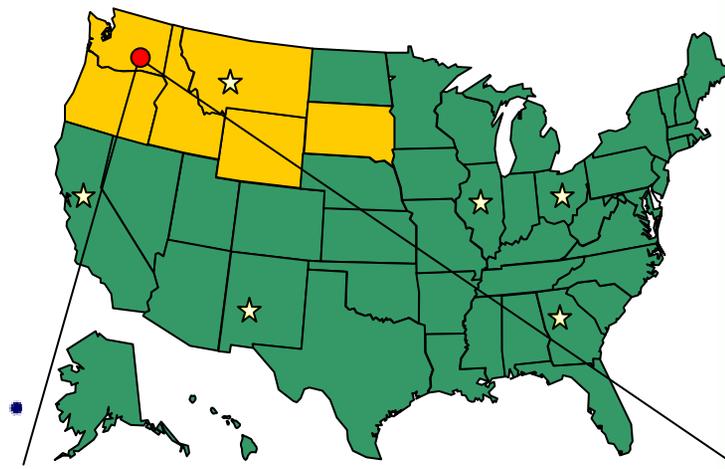
BSCSP Geologic Field Activities

- **Basalt and Mafic Rock Field Validation Test**
 - National Mafic Rock Atlas
- **Reactive Carbonate Reservoir (Madison Formation) Field Validation Test**
- **Enhanced Coal Bed Methane Recovery and CO₂ Sequestration**

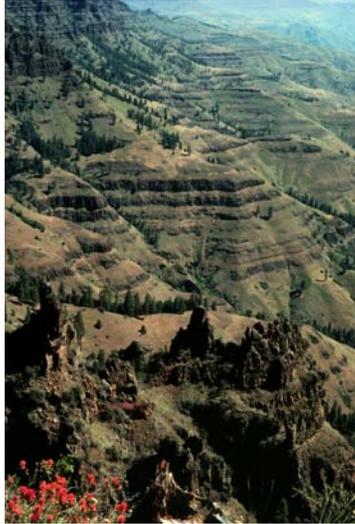


Basalt and Mafic Rock Field Validation Test

- 3000 MT of CO₂ transported by rail from refinery
- Utilize existing deep well infrastructure to minimize drilling costs for injection and monitoring
- Target is Grande Ronde basalt formation (1,100 m depth)
- Post injection core sampling to verify mineralization reactions



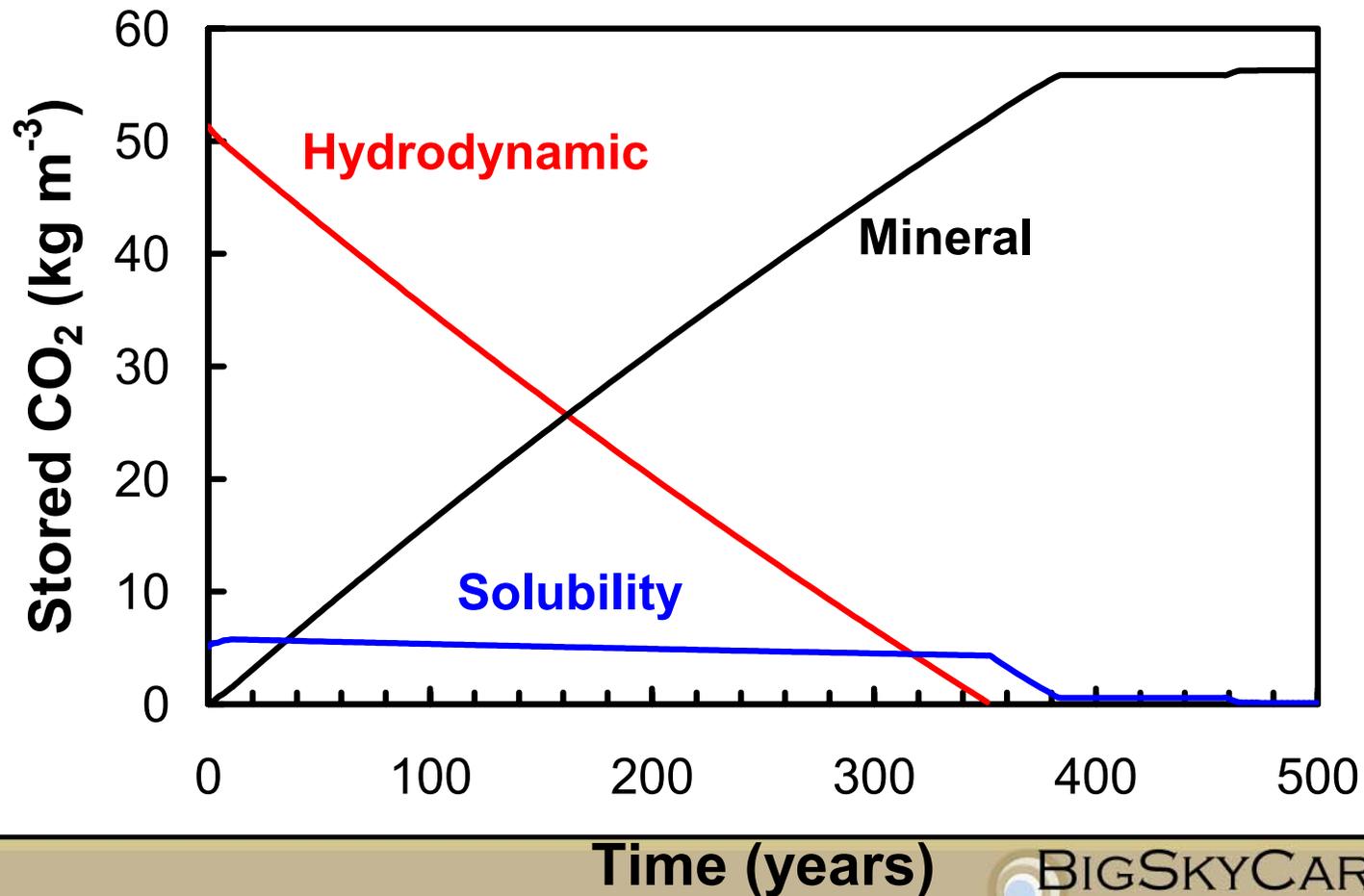
Rationale for Basalts



– Capacity and Retention

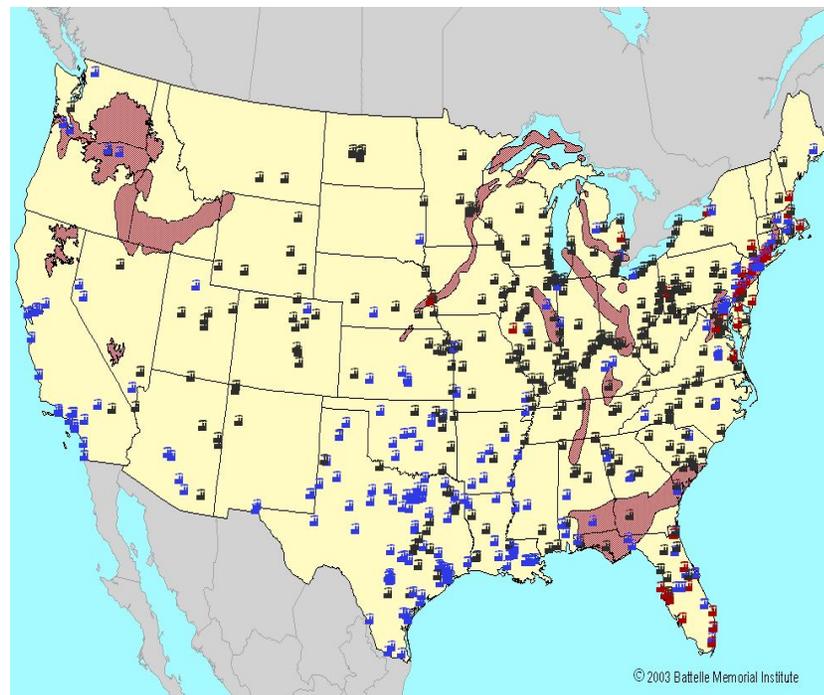
- Columbia River Basalt Group covers 164,000 km², >174,000 km³
- Chemical makeup favorable for mineralization reactions
- 3% of basalt suitable for injection
 - 100 GtCO₂ storage capacity

Hydrodynamic, Solubility, & Mineral Trapping



National Mafic Rock Atlas

- Develop a GIS-based tool that integrates
 - modeling studies
 - laboratory tests
 - pilot project insights
- Provides for transferability of pilot results nationally and internationally

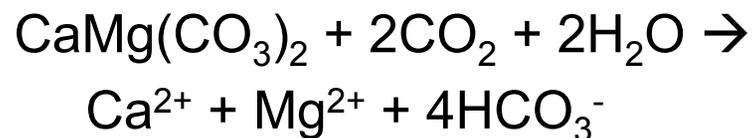


Many power plants are located near large basalt provinces

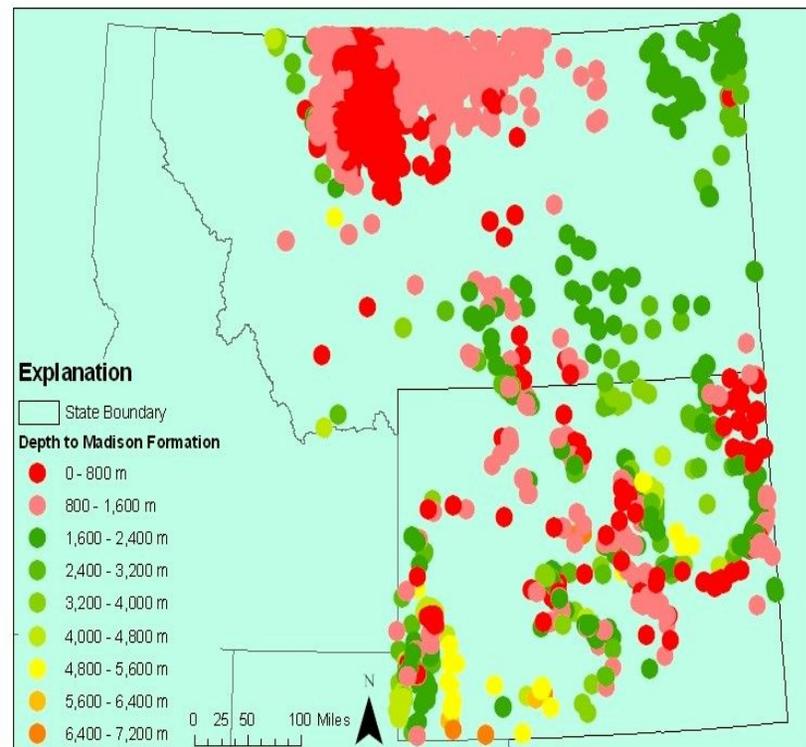
- Exist in regions with limited “conventional” capacity
- Prevalent in regions with large future electrical generation growth

Reactive Carbonate Reservoir (Madison Formation) Field Validation Test

- Regionally abundant carbonate rocks (dolomites and limestones) are highly reactive with CO₂



- Reactions should result in permeability and porosity increases



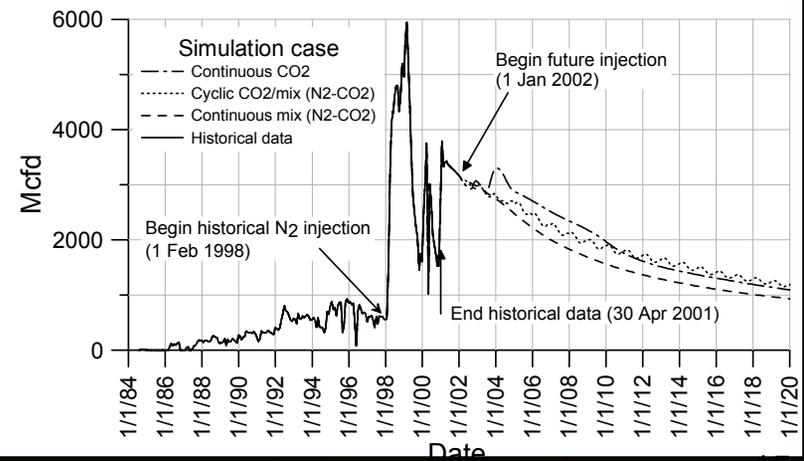
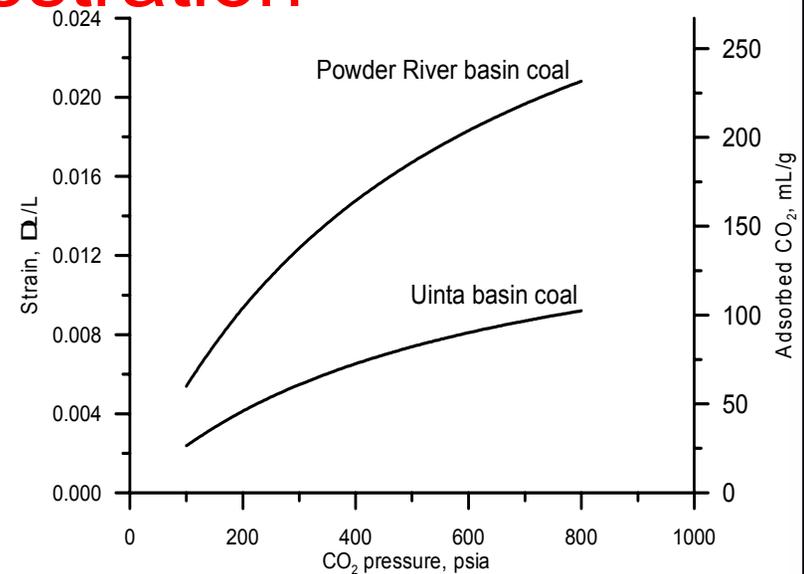
Depth to top of Madison Formation

Objective and Approach

- Assess long-term CO₂ mineralization rates in a carbonate hosted reservoir (Madison Formation)
- Collect core from reservoir that has undergone CO₂ EOR
 - long CO₂ exposure history
 - Compare to preinjection core
 - Validate predictive modeling of CO₂ injection

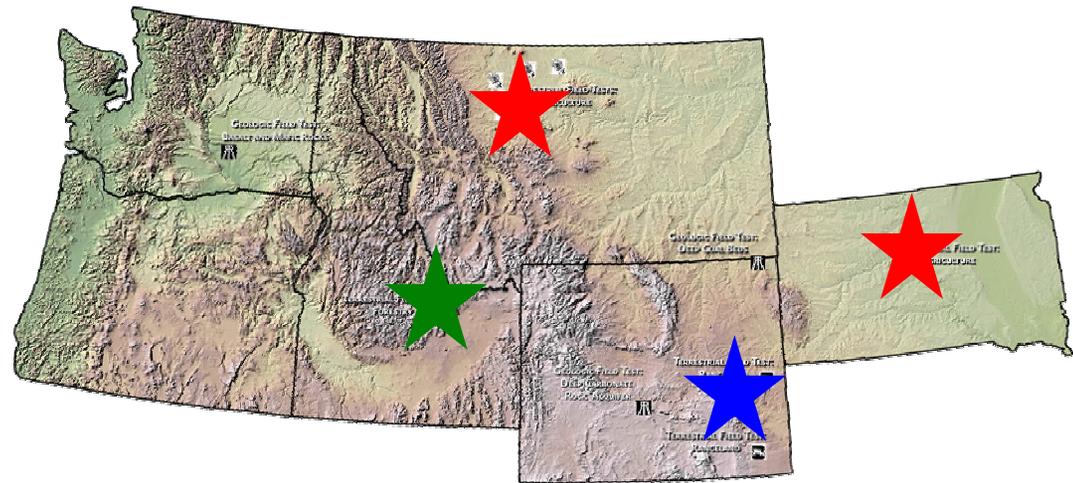
Enhanced Coal Bed Methane Recovery and CO₂ Sequestration

- Recent work shows Powder River basin coals can adsorb twice as much CO₂ as Uinta basin coals
- Study various gas injection strategies
 - Economic evaluation
 - Reservoir simulation
- Attention will be given to impact of coal swelling on permeability changes



BSCSP Terrestrial Sequestration Activities

- Carbon Markets
 - Market-based storage and verification protocols
 - Design carbon portfolios in conjunction with industry, tribal members, and landowners
- Terrestrial Pilots
 - Agriculture
 - Forestland
 - Rangeland



BSCSP Public Outreach & Education Activities

- Energy Future Coalition
- Annual Energy Forum & Report
- State Legislative Symposia
- Partnership Recognition/Media Network
- National Outreach Working Group

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