

# UW's role in carbon sequestration in Wyoming

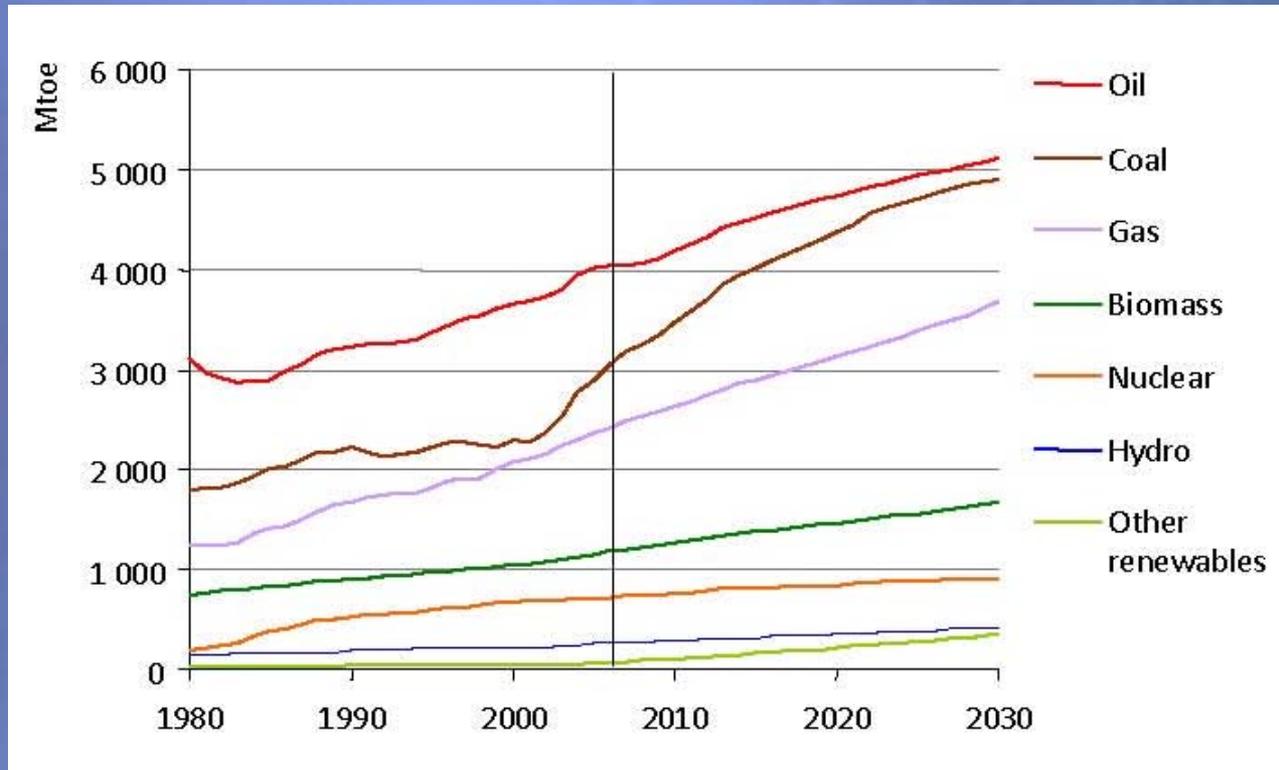
Carol Frost

Associate Vice President

Research and Economic Development

*Photo by A. W. Snoke*

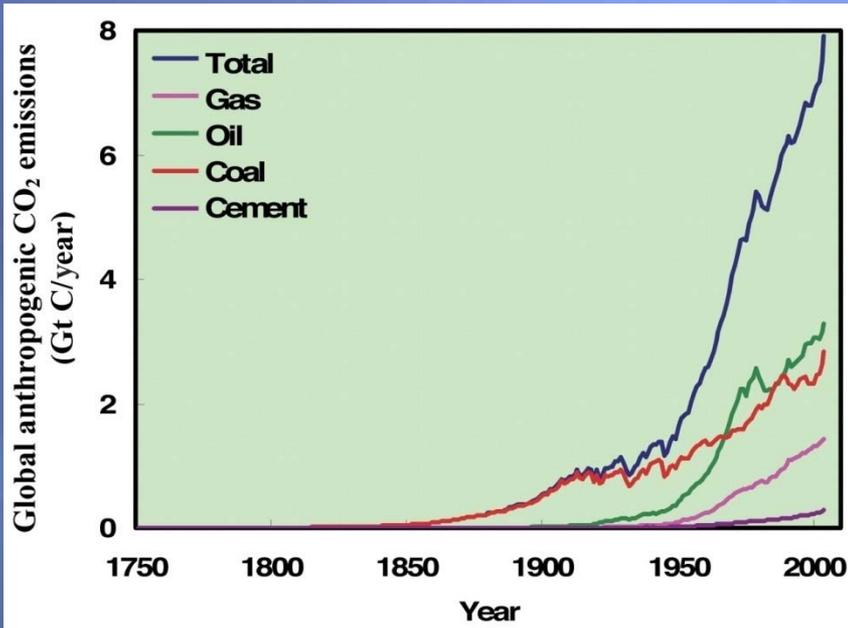
# The Global Energy Landscape



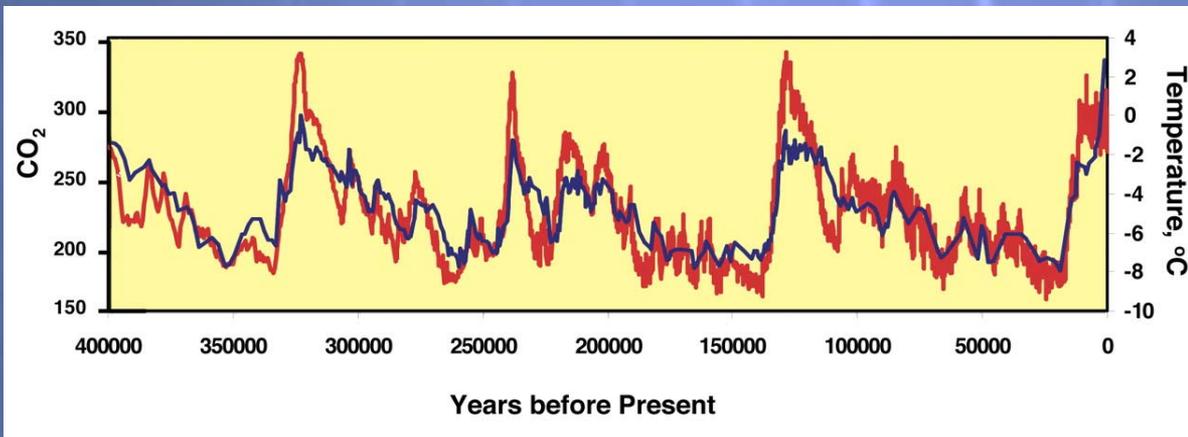
*IEA World Energy Outlook 2008*

- ✦ World energy demand will increase by 45% between now and 2030
- ✦ Coal accounts for a third of the overall rise

# Energy and Climate

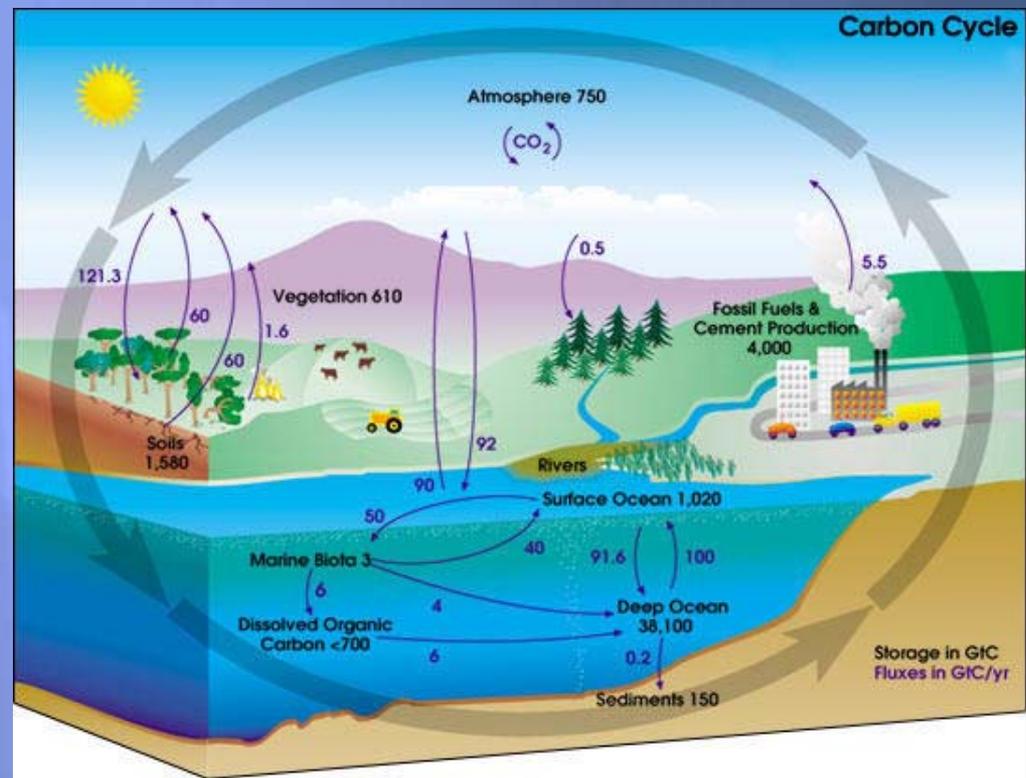


- ✦ Anthropogenic CO<sub>2</sub> emissions have raised atm. CO<sub>2</sub> levels to 385 ppm
- ✦ Atm. CO<sub>2</sub> correlates with global T

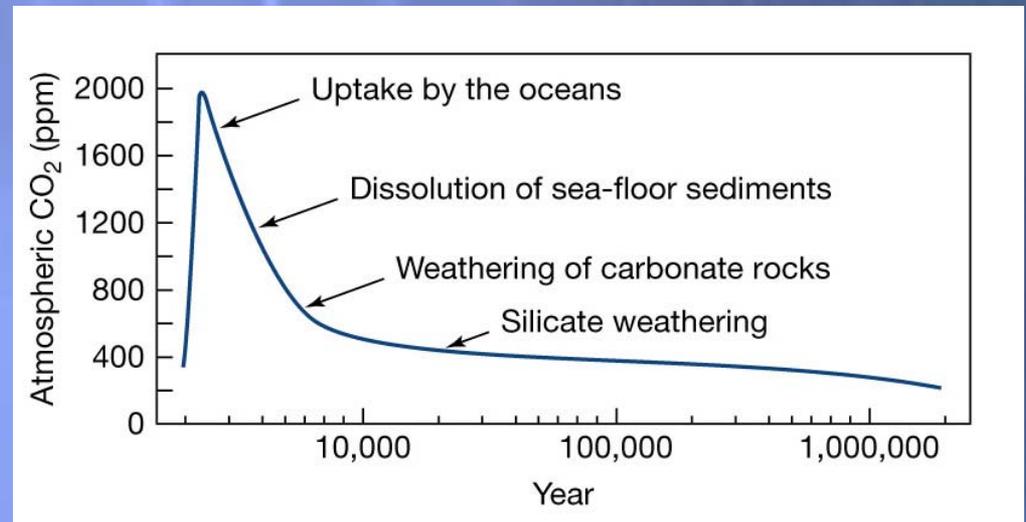


# Climate regulation

- ★ CO<sub>2</sub> is taken up in surface and deep ocean, in sediment, by weathering of rocks
- ★ Rate of CO<sub>2</sub> rise is unprecedented
- ★ Uncertain climate response



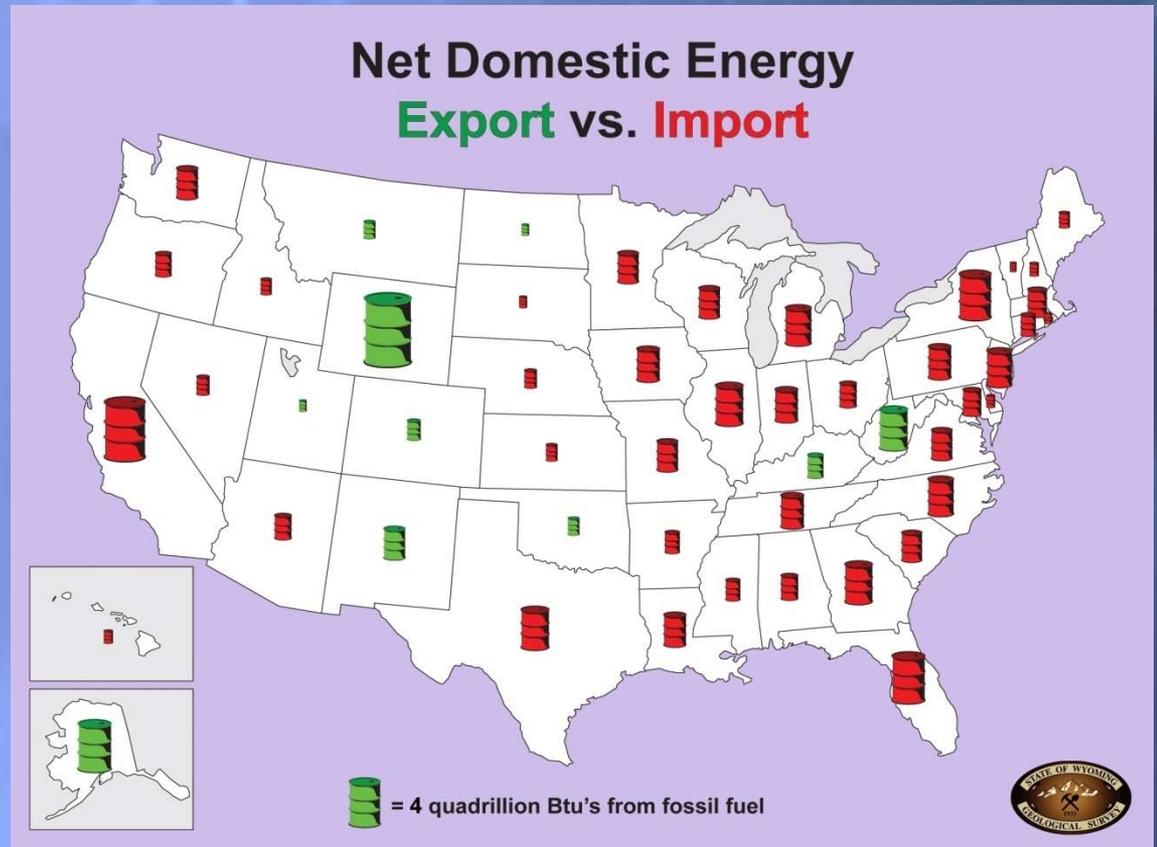
NASA



Kump et al. 2004

# Wyoming's Energy Landscape

- ✦ 53 million barrels of oil
- ✦ 2.1 trillion cubic feet of natural gas
- ✦ 467 million tons of coal
  - ✦ 40% of US coal production
  - ✦ Wyoming coal generates 30% of US electricity



# Wyoming's carbon footprint

## ✦ Individual CO<sub>2</sub> emissions: autos



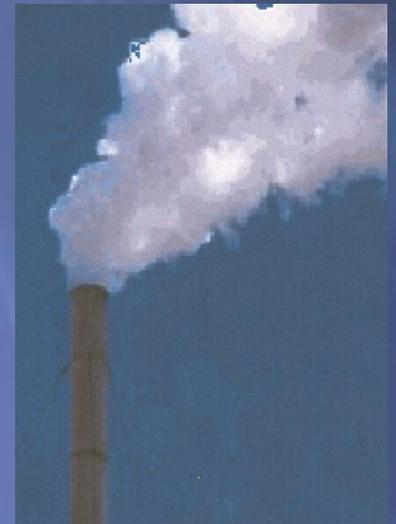
- ✦  $\text{CH}_2 + 1.5 \text{O}_2 = \text{CO}_2 + \text{H}_2\text{O}$
- ✦  $\text{CH}_2$ : 14 g/mol     $\text{CO}_2$ : 44 g/mol
- ✦ 1 kg gasoline produces 3.1 kg CO<sub>2</sub>
- ✦ 0.73 kg/l gas x 100 l (25 gal) tank = 73 kg gas per tank ---> 226 kg CO<sub>2</sub> per tank
- ✦ 24 fill-ups per year = **5.4 metric tons CO<sub>2</sub>**
- ✦ U.S. *per capita* CO<sub>2</sub> emissions = **20.6 tons CO<sub>2</sub>/yr**

# Wyoming's carbon footprint

- ✦ Per capita CO<sub>2</sub> emissions:
  - ✦ U.S. 20.6 tons CO<sub>2</sub>/yr
  - ✦ Wyoming **127** tons CO<sub>2</sub>/yr
- ✦ Wyoming emissions per capita are #1 in U.S.

*Wyoming's coal-fired power plants produce more carbon dioxide in just eight hours than the power generators of more populous Vermont do in a year.*

*Seth Borenstein, Associated Press, 2007*



# Wyoming's pro-active position on energy and climate

## ✦ Legislation

- ✦ Pore space ownership, liability, unitization

## ✦ Regulation

- ✦ DEQ regulatory authority, CSWG financial assurance mechanisms

## ✦ Science and Technology

- ✦ EORI
- ✦ Clean Coal Research Program
- ✦ High Plains Gasification Advanced Technology Center
- ✦ **Geologic carbon sequestration**



# Geologic carbon sequestration

## ✦ Essential elements

- ✦ Porous rock formations at  $> 1$  km depth
- ✦ Saline water
- ✦ Impermeable cap rock
- ✦ No leakage pathways (faults, wells)

## ✦ Wyoming's situation

- ✦ Many suitable saline formations
- ✦ Multiple caprocks
- ✦ Oil, gas,  $\text{CO}_2$ , He suggest no leakage

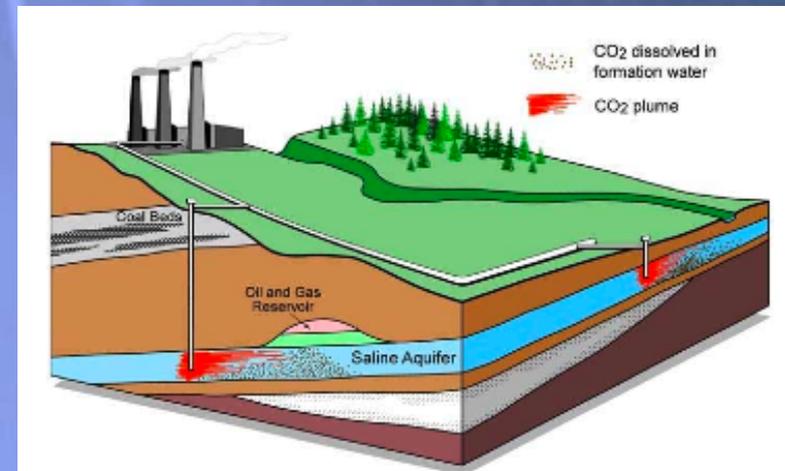


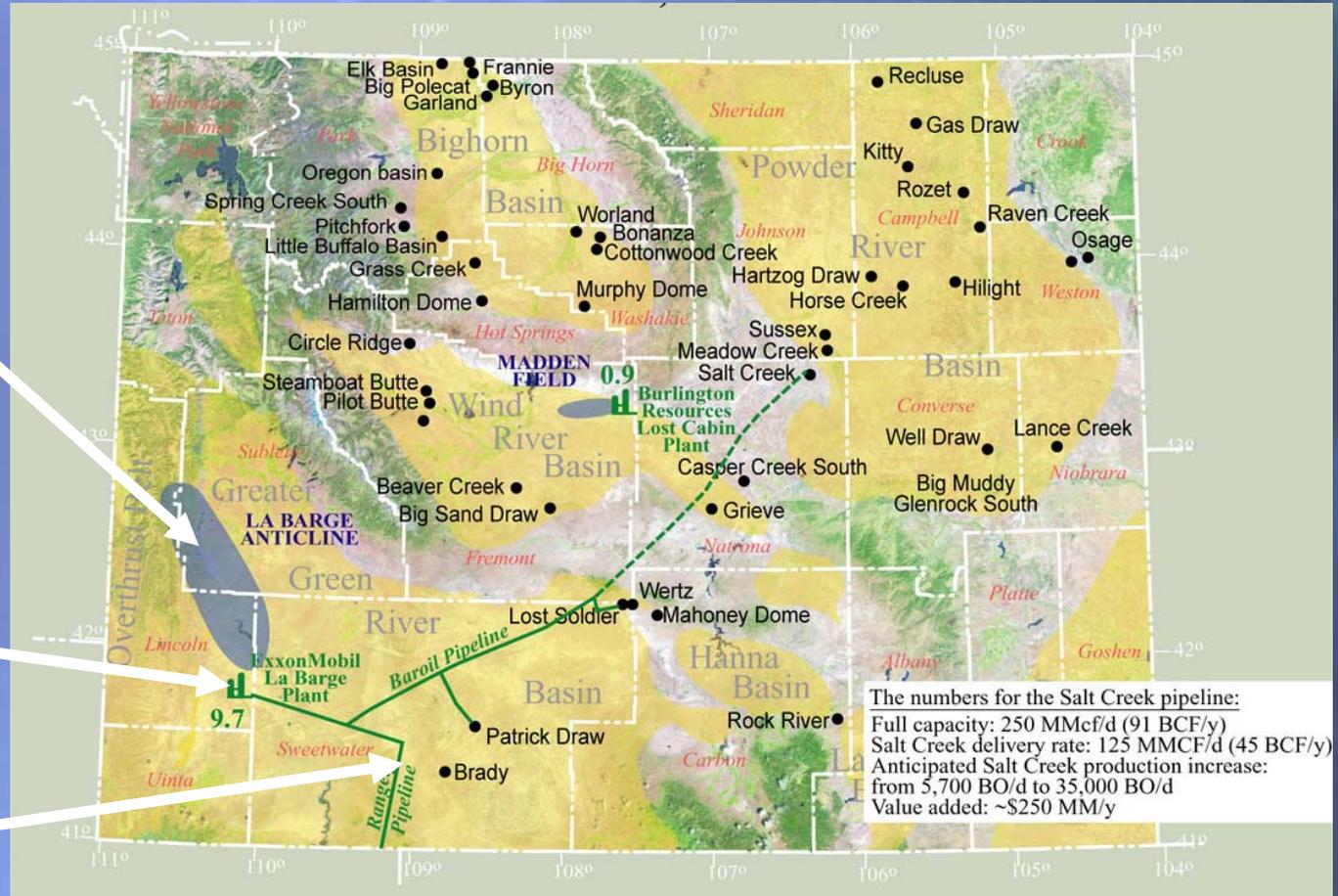
Figure 1. Image source: Dan McGee, Alberta Geological Survey

# Carbon sequestration in Wyoming

**Big Sky:  
La Barge  
Anticline**

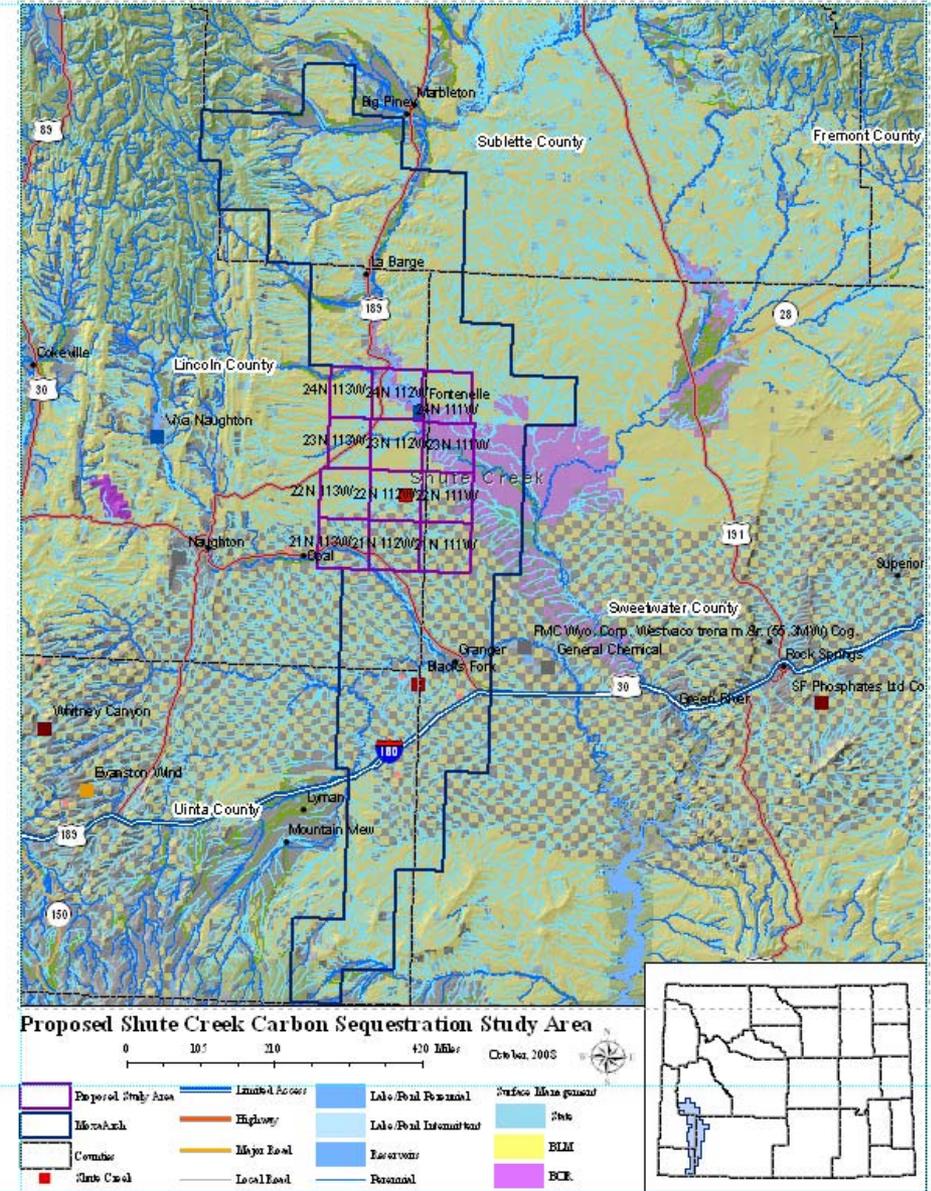
**UW/WSGS:  
Moxa  
Arch**

**WSGS/SWP:  
Rock Springs  
uplift**



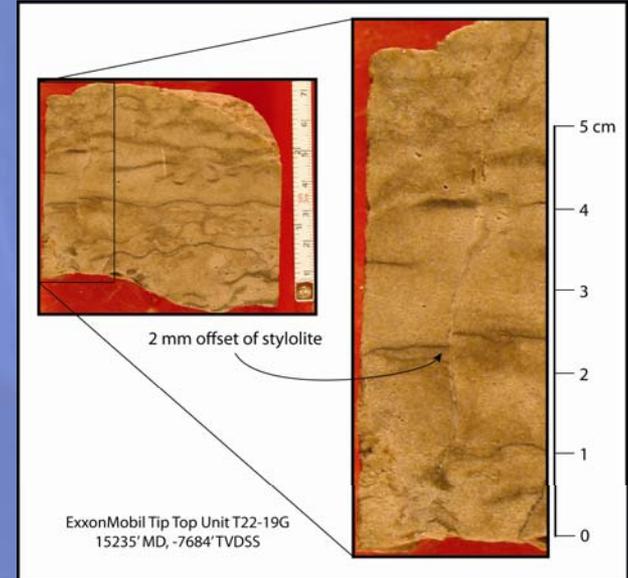
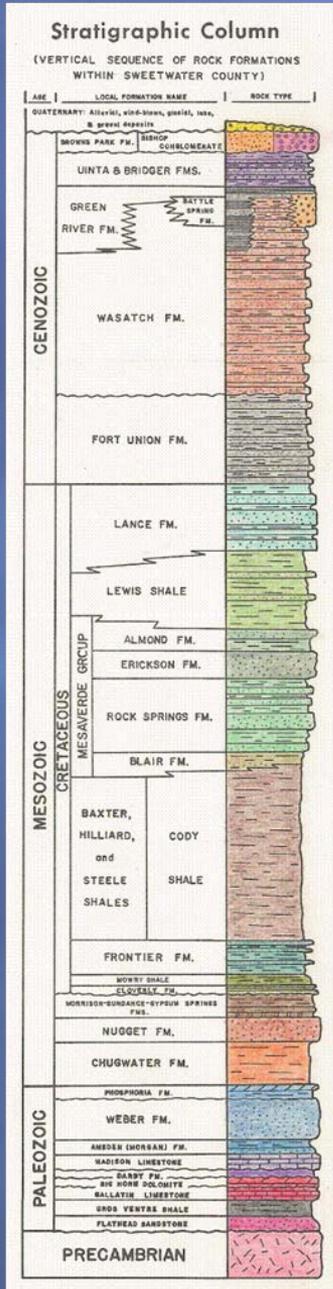
# Moxa Arch project

- ★ Funded by DOE-NETL through \$1.56 M congressional directive & \$570K UW match
- ★ Modeled on DOE Regional Partnerships
- ★ First one-year project:
  - Geologic characterization
  - Laboratory experiments
  - Modeling
  - Preliminary performance assessment model
- ★ *11 groups of faculty, post-docs, students from 3 colleges + WSGS*
- ★ *State and industrial partners*
- ★ *Project started Sept. 1, 2008*



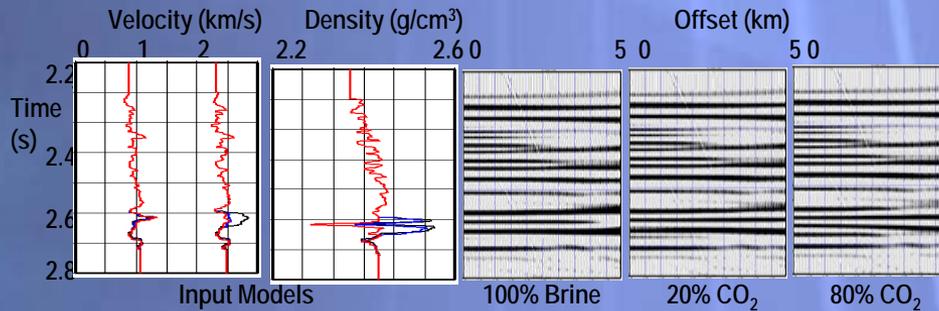
# Focus on deep reservoirs

- ✦ Below oil and gas and drinking water
- ✦ Distinctive fracture and dissolution properties determined from field and experimental study



# Creative, innovative researchers

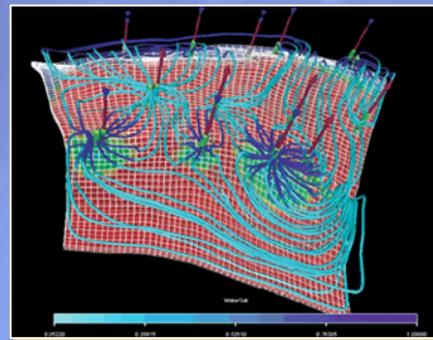
Innovative multi-component seismic waveform inversion to detect and monitor CO<sub>2</sub> in deep subsurface



Unique tomographic imaging of pore networks



New, more flexible modeling approach optimized for NCAR Supercomputing facility



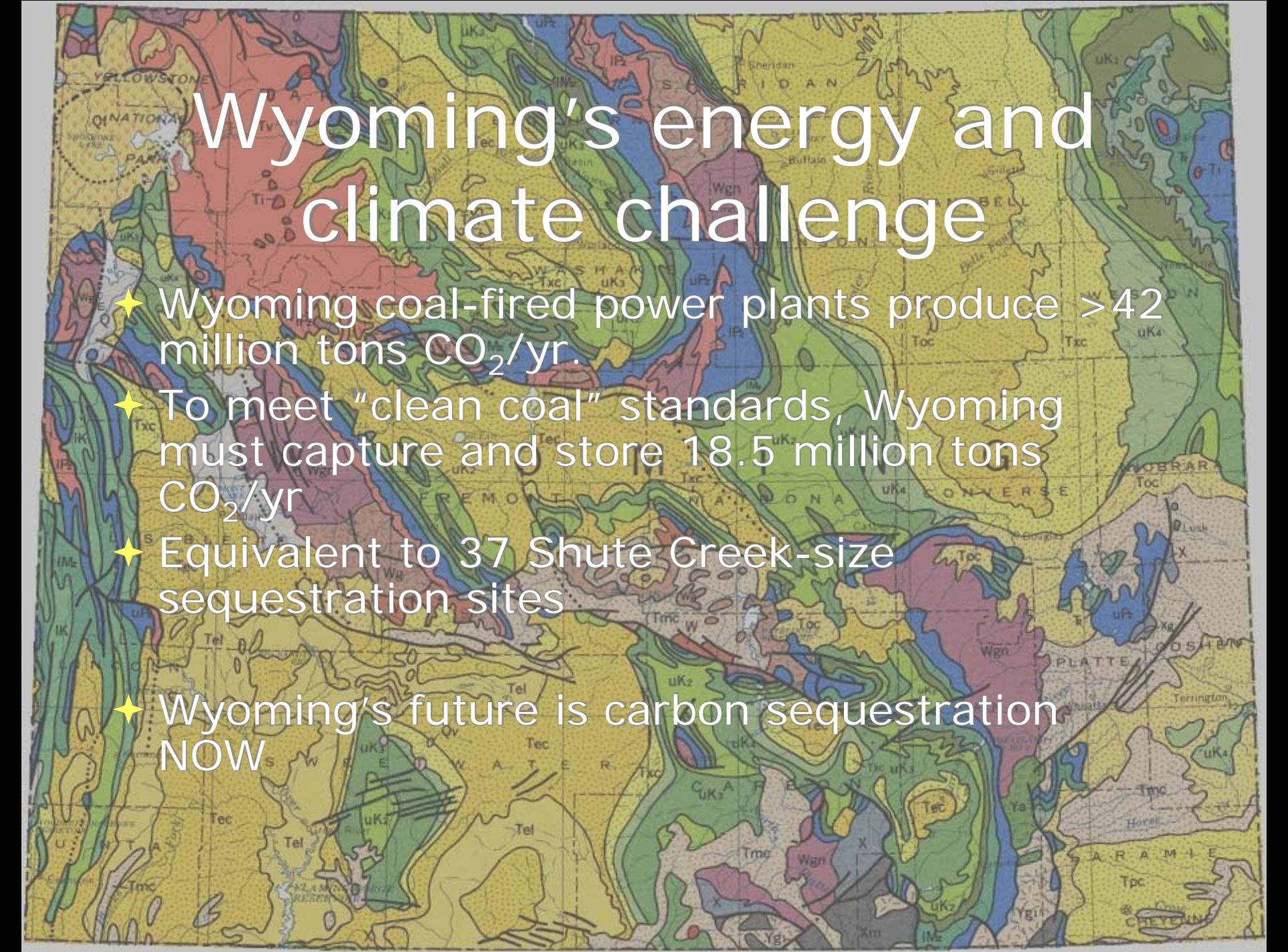
# Critical industry and state support

- ✦ ExxonMobil Shute Creek facility produces CO<sub>2</sub> for EOR
- ✦ 0.6 million tons CO<sub>2</sub>/yr sequestered
- ✦ HB/SF 1 Supplemental Budget allows WY CS to proceed
- ✦ Further DOE support in place, more sought
- ✦ Future work: location, permits, design of sequestration demonstration in WY



# Wyoming's energy and climate challenge

- ✦ Climate legislation is upon us
  - ✦ 9/29/06 California SB 1368 standard for power: not to exceed CO<sub>2</sub> emissions of gas power plants
  - ✦ 2/17/09 EPA reconsidering regulating CO<sub>2</sub> from coal-fired power plants
  - ✦ FY2010 budget includes carbon cap-and-trade
  - ✦ UN Climate Summit Copenhagen, Dec 2009
- ✦ Coal is under special scrutiny
  - ✦ Gas 117 lb CO<sub>2</sub>/million Btu energy
  - ✦ Coal 208 lb CO<sub>2</sub>/million Btu energy **78% more than gas**
- ✦ Wyoming coal-fired power plants produce >42 million tons CO<sub>2</sub>/yr.

A geological map of Wyoming, showing various geological units and features. The map is color-coded and includes labels for various geological units such as uK2, uK3, uK4, Txc, Tmc, Wgn, and others. Major cities like Sheridan, Buffalo, Torrington, and Cheyenne are also marked. The map is overlaid with a grid. The title "Wyoming's energy and climate challenge" is prominently displayed in the upper center.

# Wyoming's energy and climate challenge

- ★ Wyoming coal-fired power plants produce >42 million tons CO<sub>2</sub>/yr.
- ★ To meet "clean coal" standards, Wyoming must capture and store 18.5 million tons CO<sub>2</sub>/yr
- ★ Equivalent to 37 Shute Creek-size sequestration sites
- ★ Wyoming's future is carbon sequestration NOW

...there is one outstandingly important fact regarding Spaceship Earth, and that is that no instruction book came with it.

*R. Buckminster Fuller (1895-1983)*