Producing Coalbed Methane with Simultaneous CO_2 Sequestration

K. Jessen, M. Sahimi, and T. T. Tsotsis

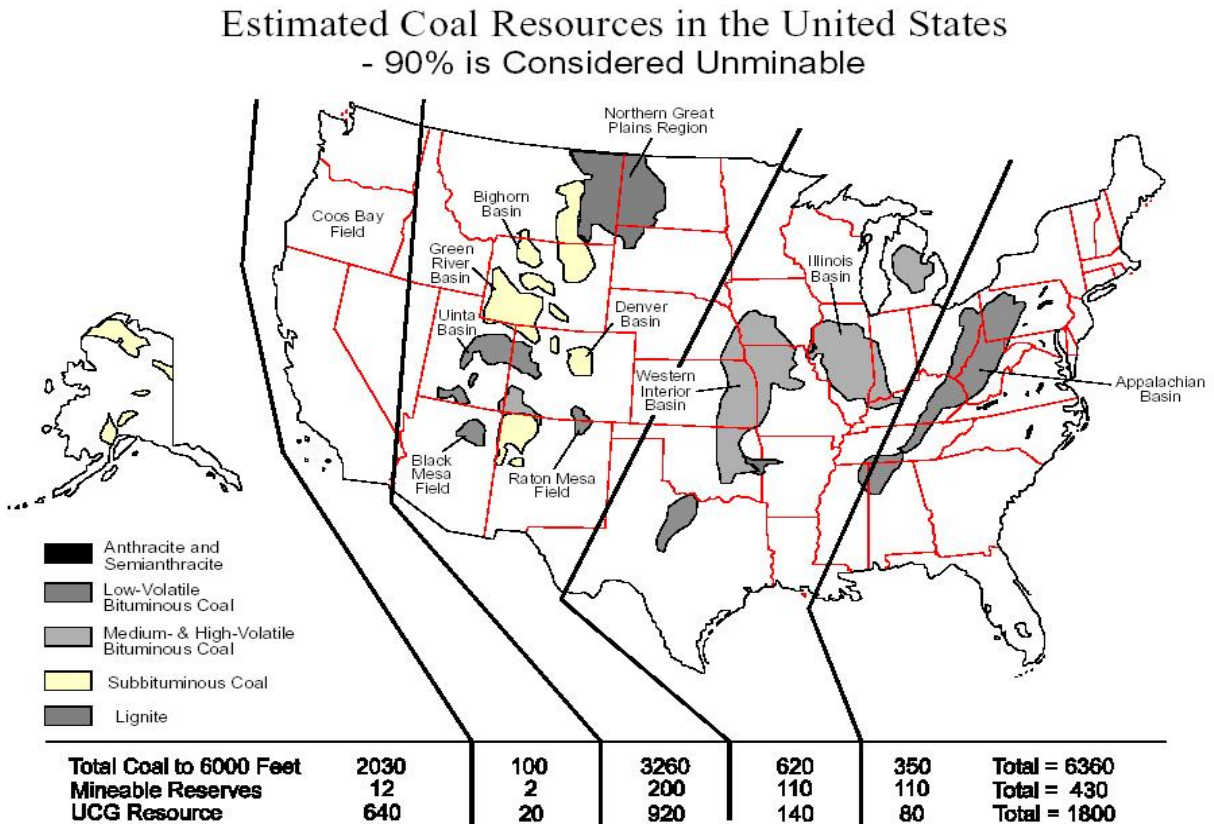
Mork Family Department of Chemical Engineering and Materials Science,
University of Southern California,
Los Angeles, CA 90089-1211

Motivation

- Coalbed methane (CBM) reservoirs contain a very significant amount of CH_4.
- Carbon surfaces have strong affinity for adsorbing CO_2.
- Therefore, the basic idea is to adsorb and trap CO_2 within the pores of CBM reservoirs, and to extract a significant amount of CH_4 as a substantially clean source of energy.

- Estimated coal resources in the U.S. total nearly six trillion tons to a depth of 6,000 feet with 90% of this amount considered unminable with current technology.

  – Source DOE



Motivation (cont.)

- The main source of anthropogenic CO_2, the major player in the “Green House” effect and air pollution, is the combustion of fossil fuels.
- United States, the world's largest emitter of CO_2 emits close to 5,500 Metric Tons per year.
- Aim is to find a long-term solution to alleviate the global warming problem by keeping CO_2 in check and at the same time making it economically favorable by producing CH_4, a clean source of energy.

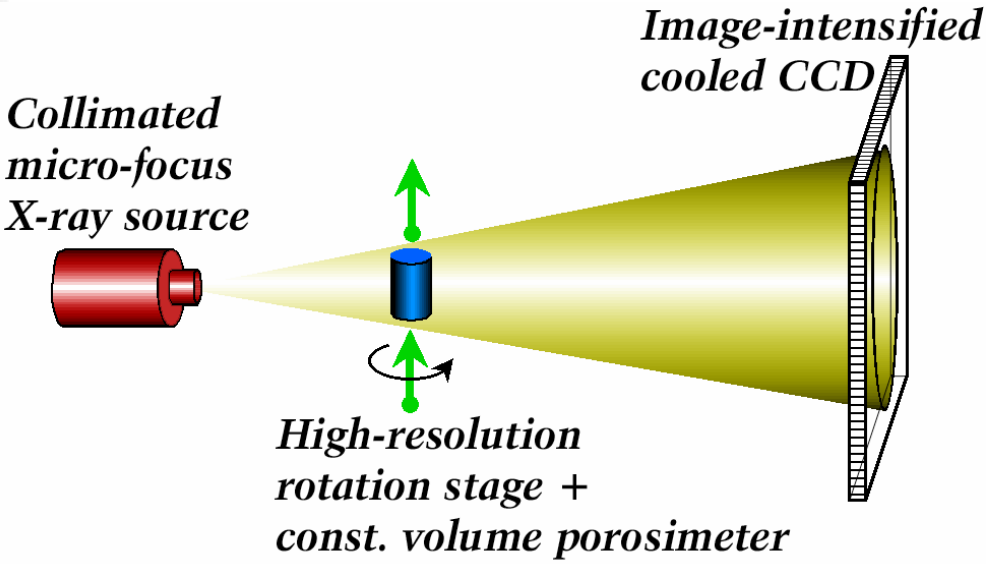
Project Outline

- Simulating, modeling and forecasting the behavior of CBM reservoirs for adsorbing CO_2 and desorbing CH_4 requires a realistic model representing the fracture network and pore space.
- CBM reservoirs are characterized by pores at various length scales, ranging from the micropores, where CH_4 and CO_2 diffuse and adsorb, to mesopores, macropores, cleats and fractures at the largest length scale.
- Although commercial software programs, such as ECLIPSE and GEM, are available, without proper modeling of the microscopic, mesoscopic, and macroscopic scales, and proper scale-up of the model, the simulation results will not be reliable.

Project Outline (cont.)

- CBM are anisotropic porous media characterized by a permeability tensor. Careful measurements of the effective permeabilties and other properties at all length scales are needed.
- Such permeabilities depend on pore/fracture size distribution, and pore/fracture connectivity.
- Our approach is to use a variety of non-destructive techniques to characterize the porous structure at different length scales. They include high resolution X-ray tomography, flow permporometry, and probe gas adsorption.
- These are coupled with measurements of the permeability tensor and lab-scale CO_2 sequestration experiments.

Scanning, Imaging & Characterization

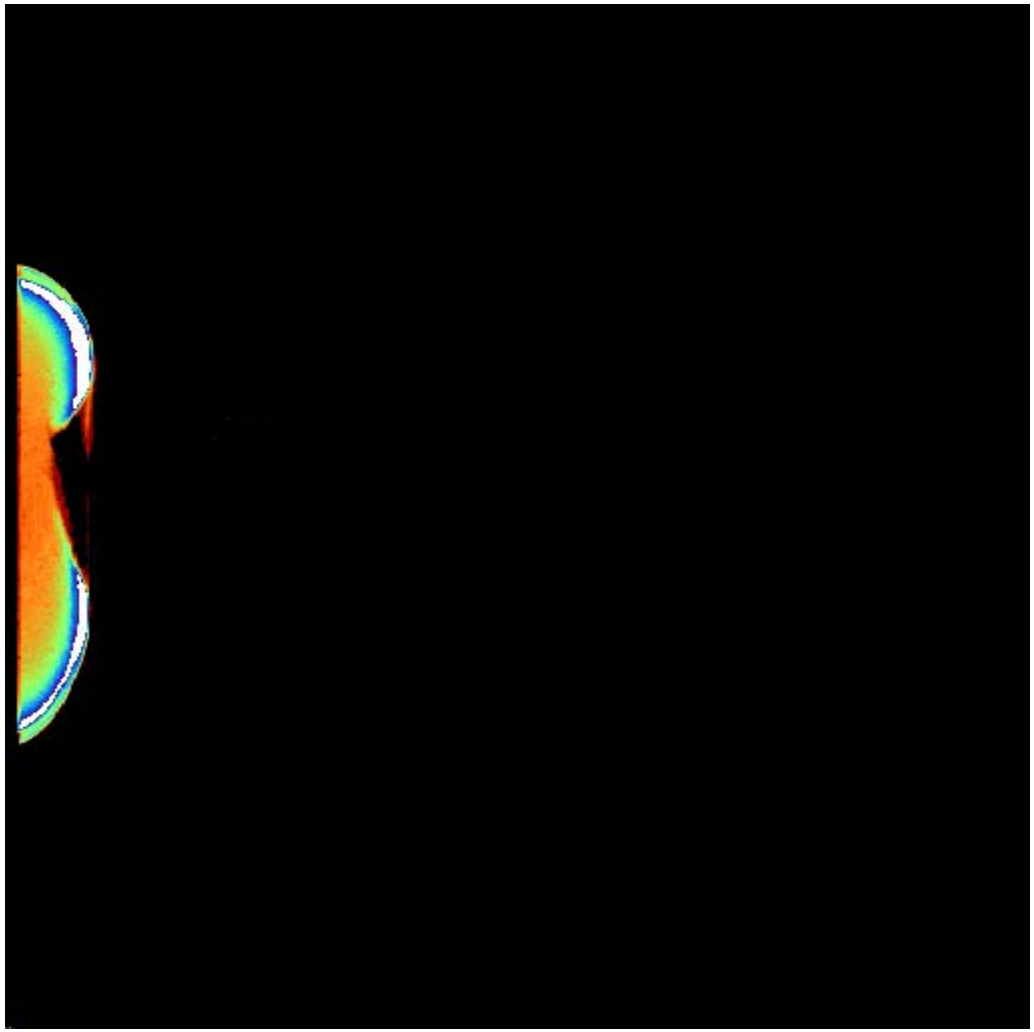


Micro-CT source: Measurement at 2 micron resolution

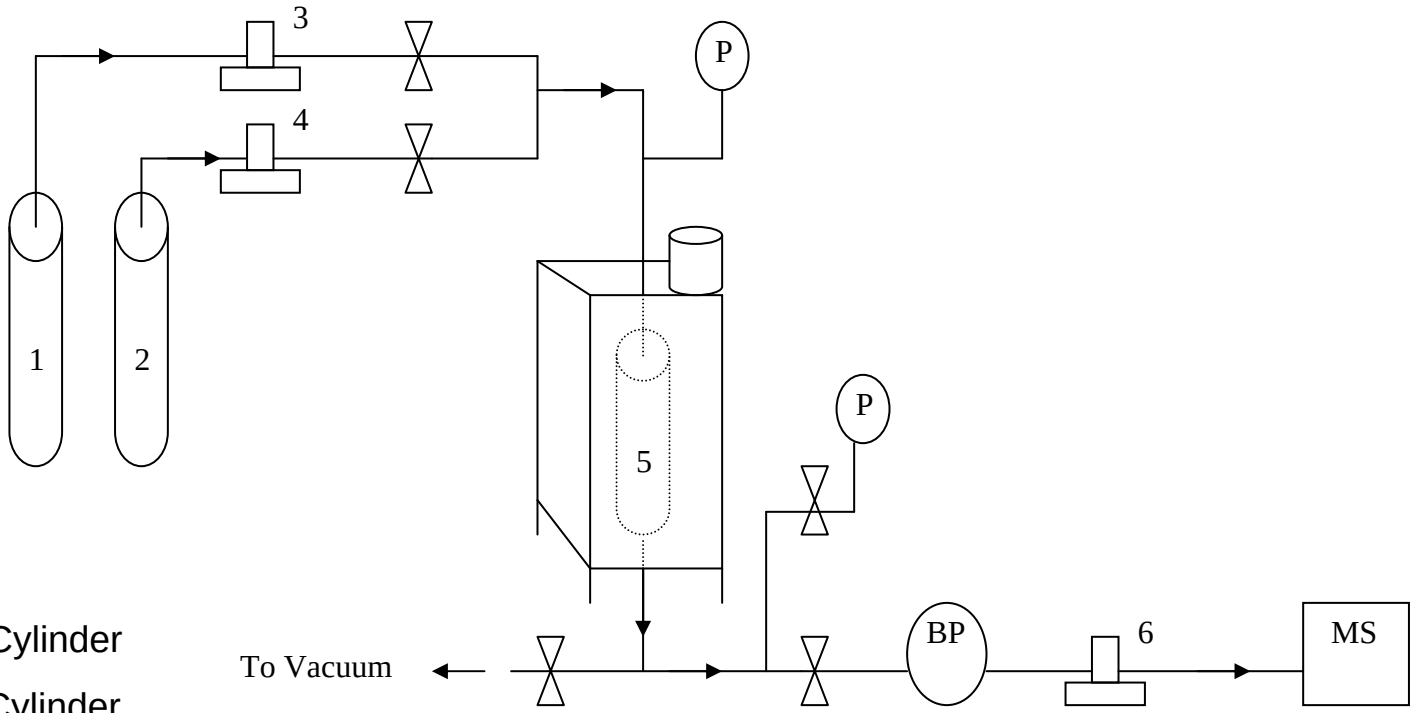
Interactive Visualisation

Characterisation of Pore space

Tomography…In real time video…



Experimental Setup



1 - CO_2 Cylinder

2 - CH_4 Cylinder

3 & 4 – Mass Flow Controllers

5 – High Pressure Chamber

6 – Mass Flow Meter

P – Pressure Gauge

BP – Back Pressure Regulator

MS – Mass Spectrometer

Summary

- N_2 adsorption/desorption data (micro & meso scale) and Permporometry (macro scale) give us a good idea of pore size distribution over the coal sample.
- Lab-scale CO_2 sequestration experiments help provide data to carry out CO_2-CH_4 adsorption/desorption simulations.
- Tomography techniques assist in creating realistic models for pore networks in coal.
- Future work will use field-level data to carry out simulations on a larger (reservoir) scale.