Enhanced Recovery of Coal Bed Methane and Heavy Hydrocarbons

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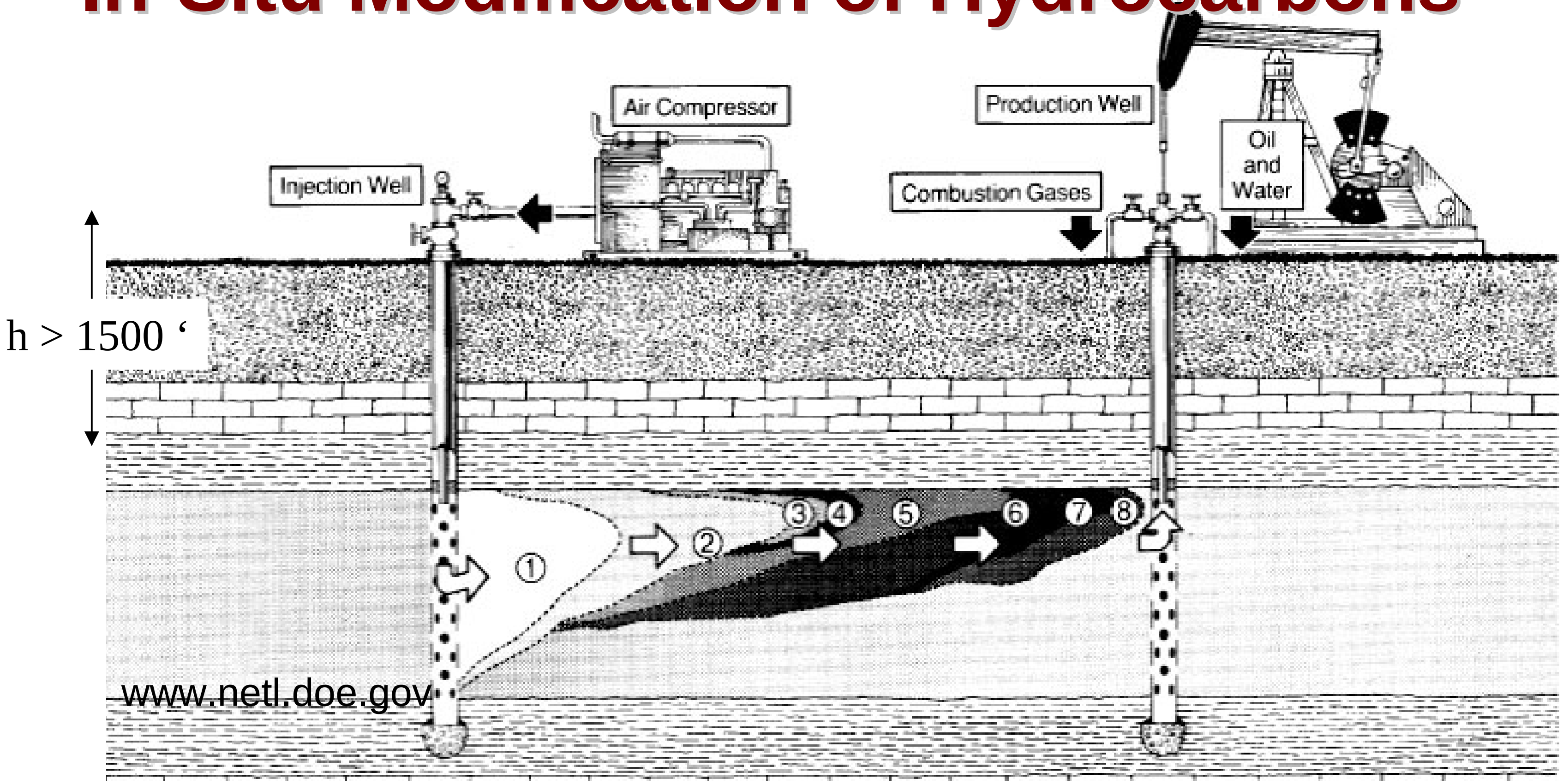
Outline

- Introduction to unconventional resources recovery research at Stanford
- Upgrading using in-situ combustion
- Enhanced coalbed methane

What is the SUPRI-A project about?

- **We conduct a complete spectrum of research related to increasing the recovery from unconventional hydrocarbon resources such as coalbeds, heavy oil, and low permeability fractured systems.**
- **We educate students so that they are prepared for challenging and rewarding careers in energy.**

In-Situ Modification of Hydrocarbons



1. Injected Air
2. Burned Zone
3. High Temperature Oxidation (HTO)
4. Cracking, Pyrolysis, and Low Temperature Oxidation (LTO)
5. Vapor Zone
6. Condensation
7. Oil Bank
8. Displaced fluid

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Low (h<1500’) vs high (h>1500’) pressure

- **inject air or a combination of oxygen and recycled CO_2**
- **modest upgrading of 0-6 °API**
- **sulfur removal from crude**

- **coinject air (or O_2&CO_2) and water**
- **can engineer processes similar to in-situ coal gasification**
- **easier to manage subsurface flows in comparison to coal**

Challenges: In-Situ Modification

Clearly not inclusive

- kinetics
  - dominant reactions
  - relevant side reactions (e.g. sulfur rejection)
  - rates and rate parameters
- laboratory-scale (3’) facilities
- simulation of reactive transport with heat transfer
  - multiple time scales
  - efficient, specialized solvers
  - adaptive mesh refinement

Enhanced Coalbed Methane

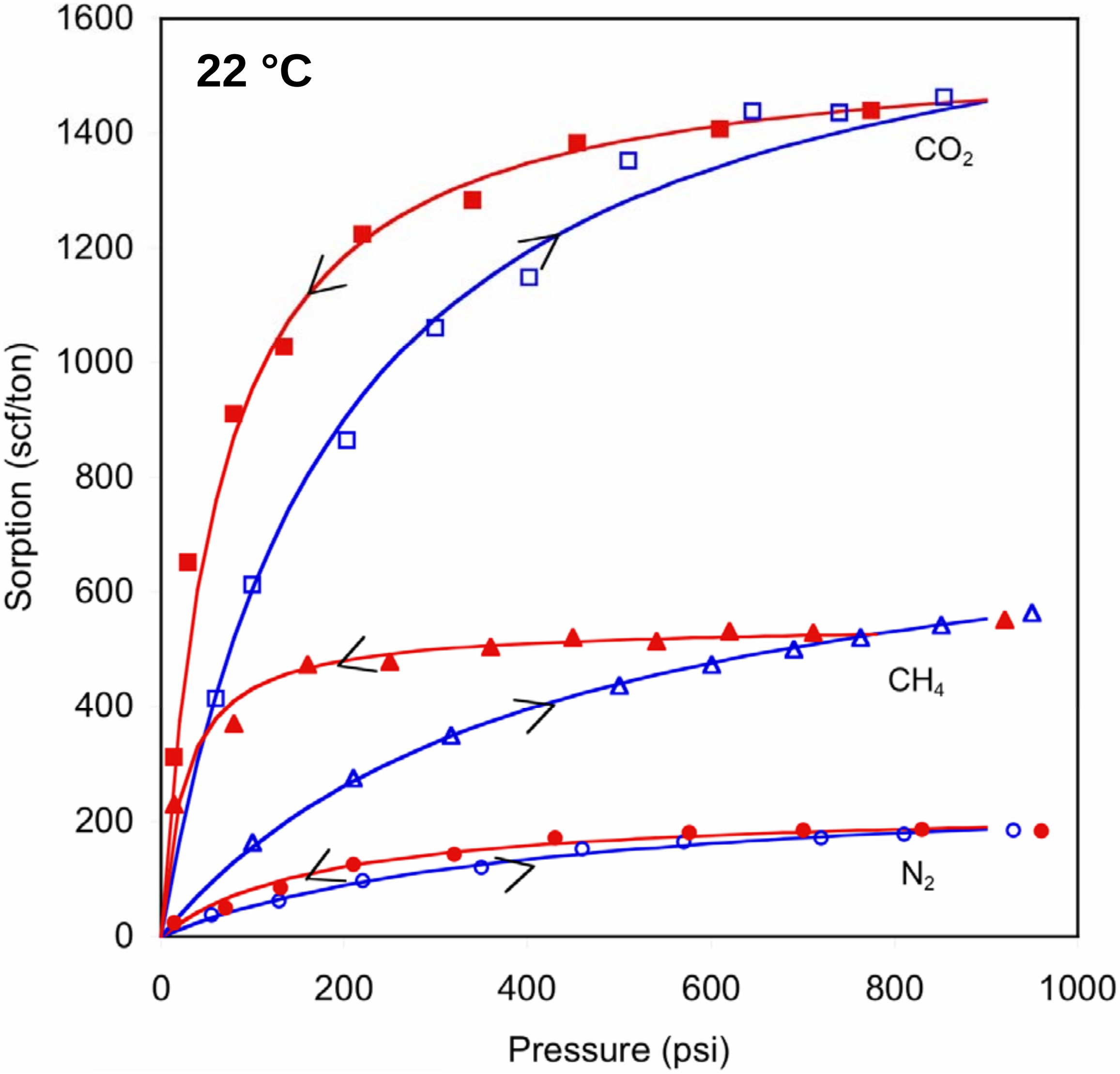
- Elucidate fundamental mechanisms relevant to enhanced methane production and greenhouse/acid gas storage in coal because poor predictions result, in part, from incomplete knowledge of physical mechanisms.
- Reduce, potentially, volumes of produced water.
- Our niche is our ability to probe simultaneously sorption, transport, and permeability to gas
    - experimentally
    - analytically
    - numerically

How much gas adsorbs?

CO_2, CH_4, N_2 Sorption, Tang, Jessen, and Kovscek SPE 95947

Ground Powder River Basin (WY) Coal

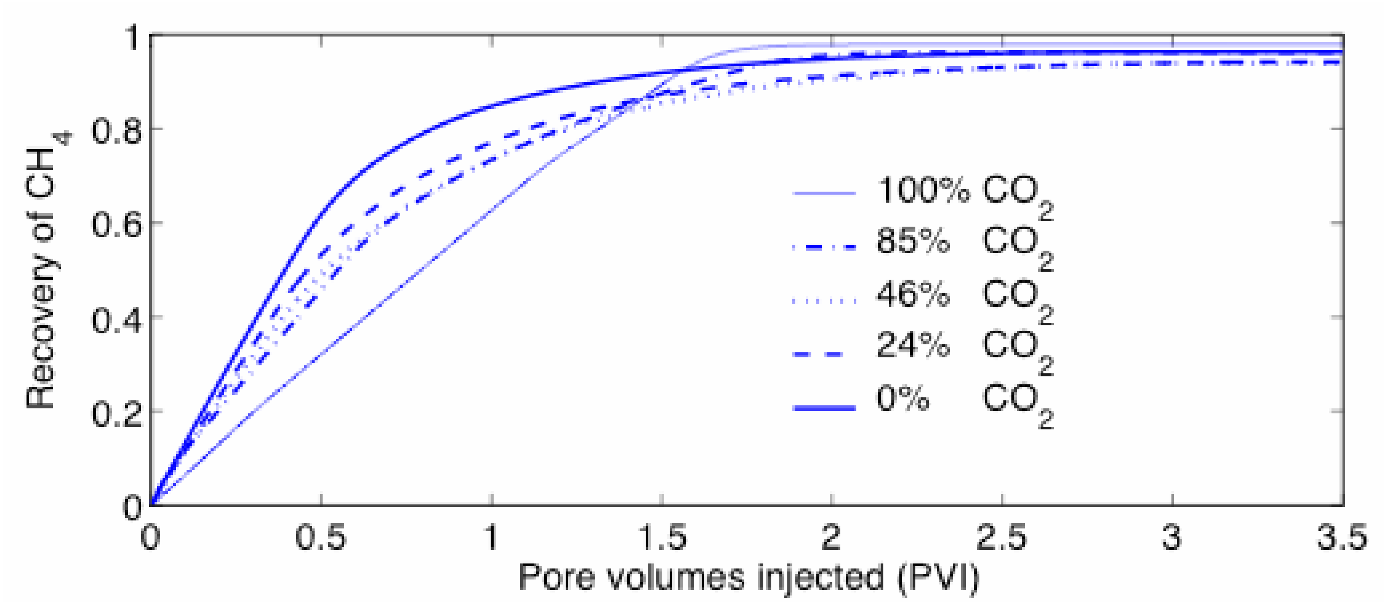
- **Pure components are well fit by Langmuir isotherm**
- **CO_2 adsorbs preferentially**
- **adsorption hysteresis for all gases**



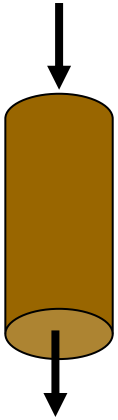
Ternary Gas Systems, ϕ_2=7.4%

Tang, Jessen, and Kovscek SPE 95947

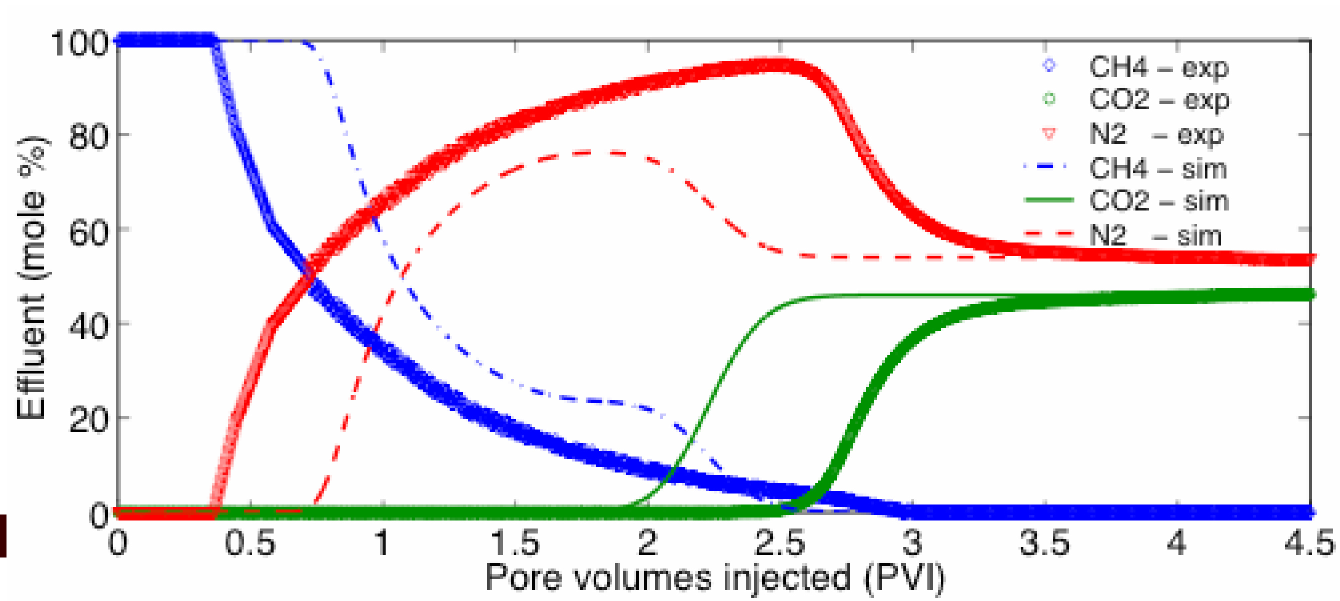
experiment



54%N_2+46% CO_2



CH_4 + N_2 + CO_2



Challenges: Transport and Sorption

- physical description:
  - what level of sophistication necessary for multicomponent adsorption isotherms
  - evolution of matrix versus gas and moisture content
- characterization of relevant time scales within laboratory and field
- extension of detailed understanding to field scale