Recommendations for Basic Scientific Research Needs for Geological Storage of CO_2

Sally M. Benson

Energy Resources Engineering Department

Stanford University

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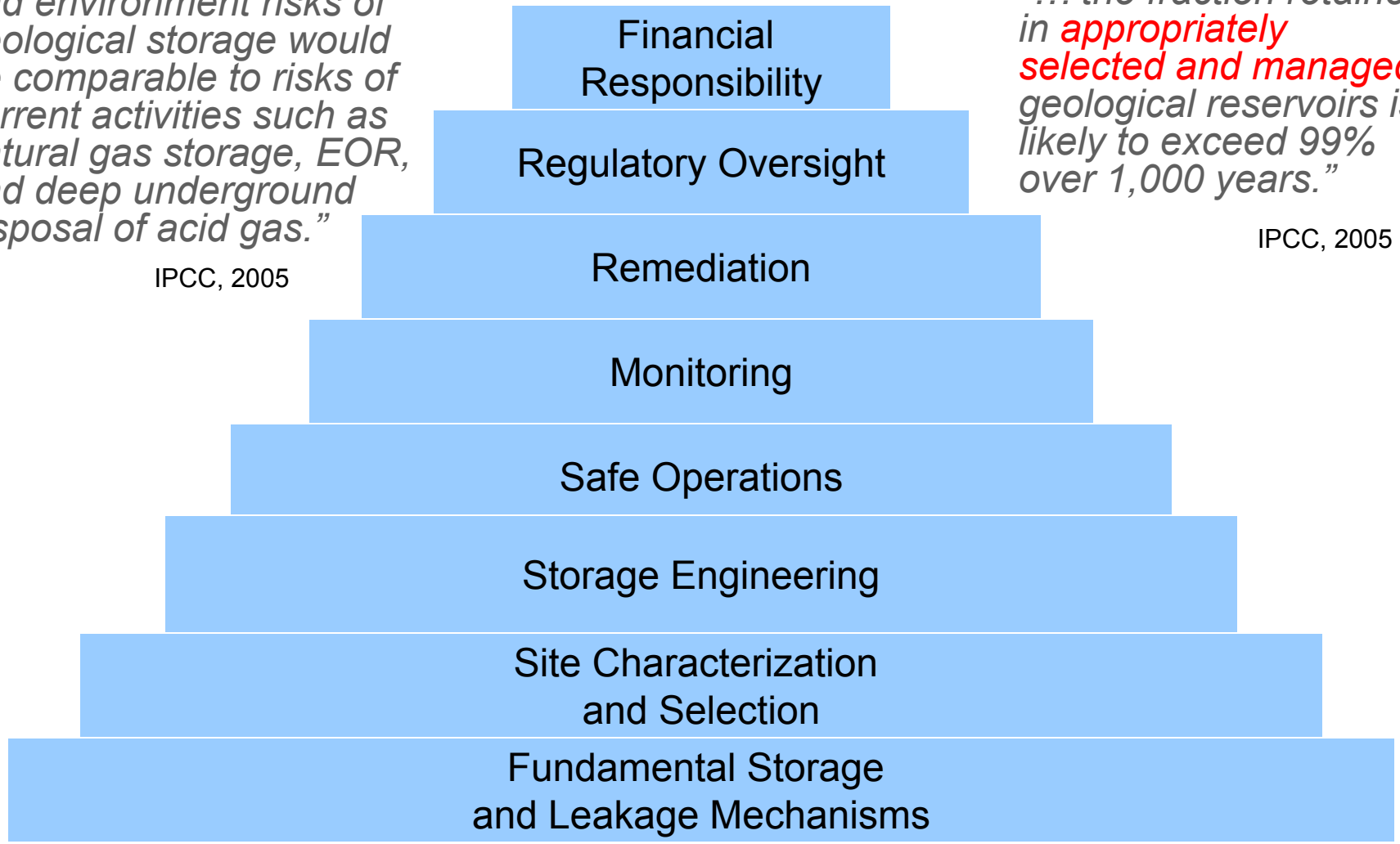
Geological Storage Safety and Security Pyramid

"… the local health, safety and environment risks of geological storage would be comparable to risks of current activities such as natural gas storage, EOR, and deep underground disposal of acid gas."

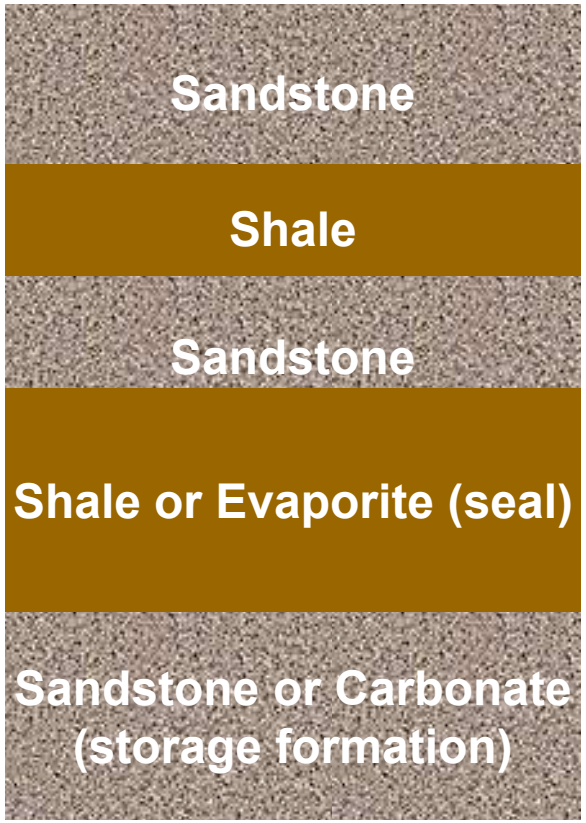
IPCC, 2005

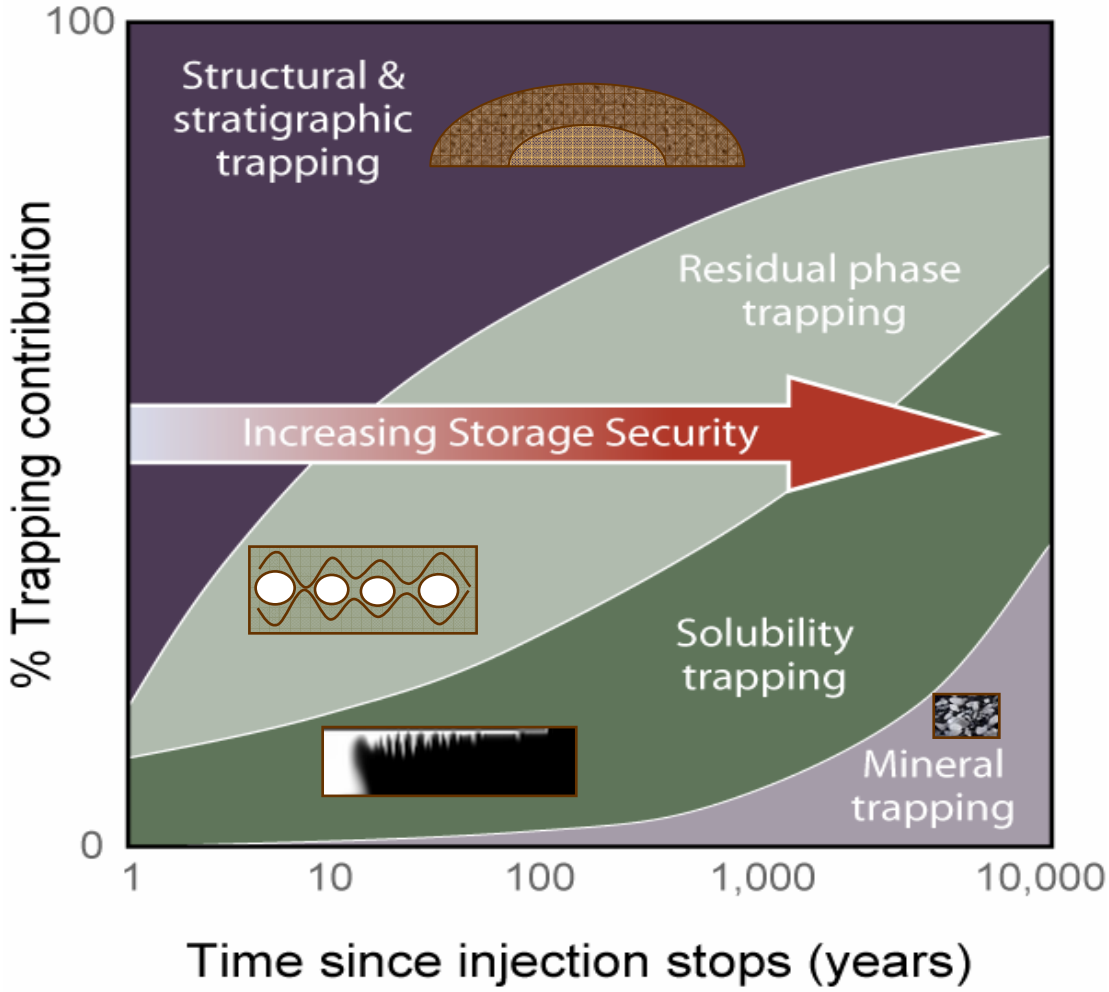
"… the fraction retained in appropriately selected and managed geological reservoirs is likely to exceed 99% over 1,000 years."

IPCC, 2005

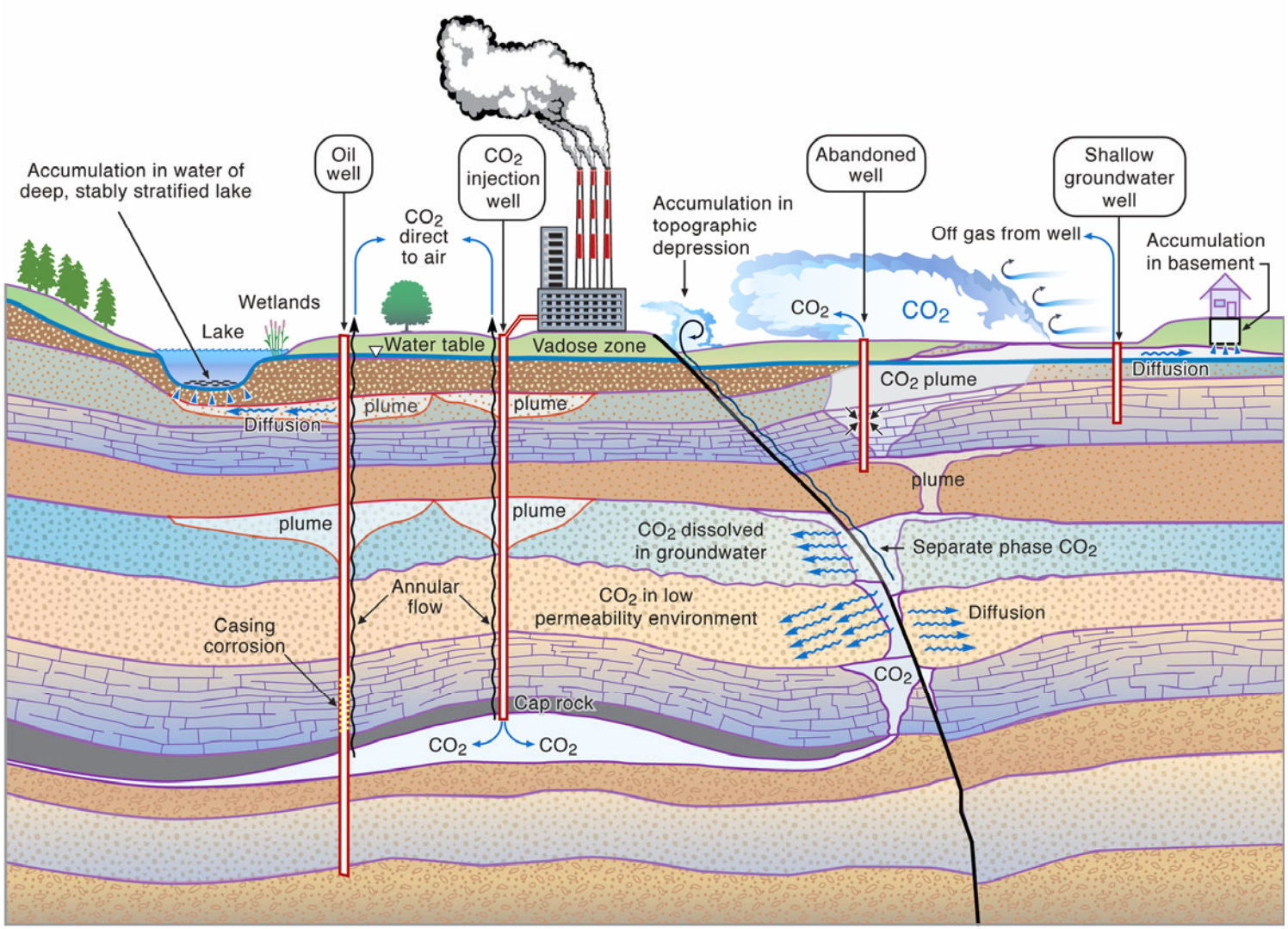


Primary and Secondary Trapping Mechanisms





Leakage Mechanisms



Fundamental Research Challenges

We need to understand both

- storage and leakage mechanisms -

with a high degree of confidence.

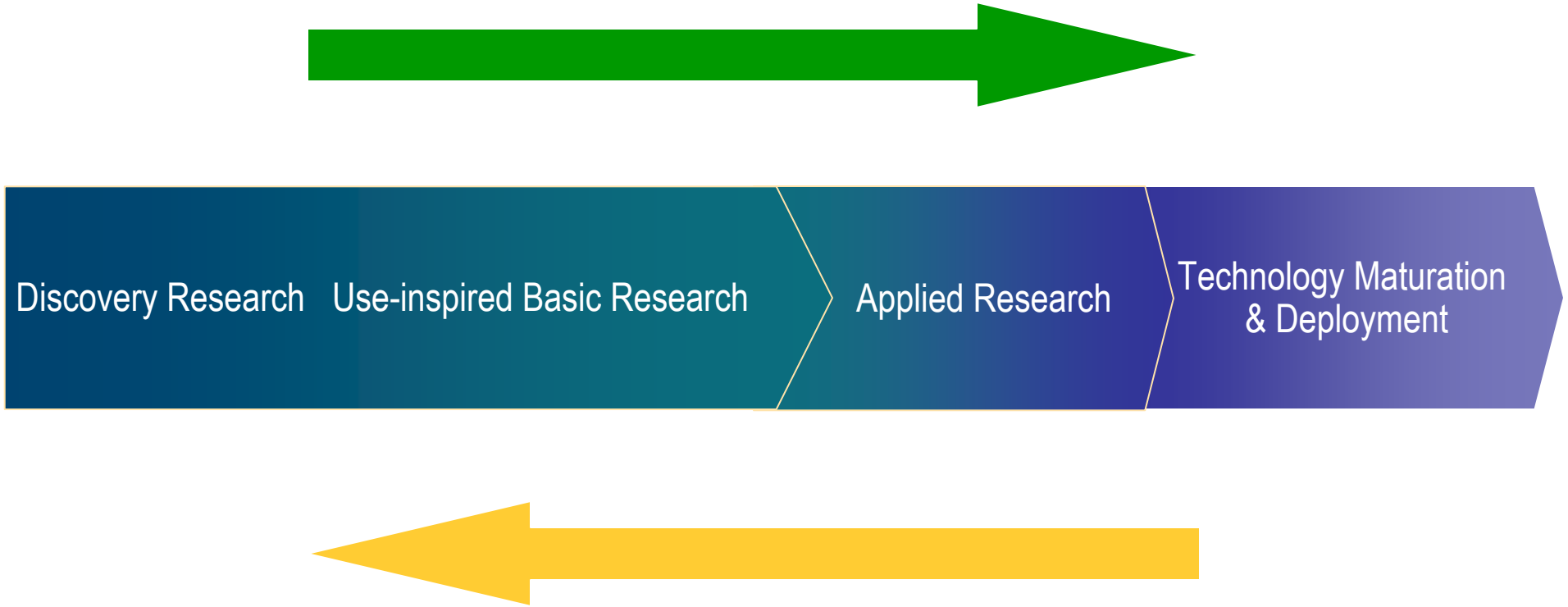
DOE Office of Science: Basic Energy Sciences

- A multi-purpose, scientific research effort to foster and support fundamental research to expand the scientific foundations for new and improved energy technologies and for understanding and mitigating the environmental impacts of energy use.

- The portfolio supports work in the natural sciences, emphasizing fundamental research in materials sciences, chemistry, geosciences, and aspects of biosciences.

The Office of Science is the single largest supporter of basic research in the physical sciences in the United States, providing more than 40 percent of total funding for this vital area of national importance.

Linkages Between Fundamental Research and Technology Deployment



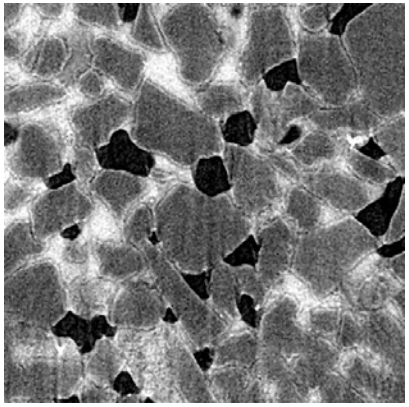
Office of Science	Applied Energy Offices
BES	EERE, NE, FE, TD, EM, RW, …

Priority Fundamental Research Directions in Geological Storage of CO_2

1. Influence of heterogeneity at all scales on plume migration
2. Geochemical reactions and kinetics in multi-phase flow systems
3. Dynamic imaging for complex multi-phase systems
4. Geomechanical and hydrological effects of large anthropogenic perturbations
5. Flow and transport properties of seals, faults, and fractures

Effects of Heterogeneity at Every Scale on Multi-Phase Flow

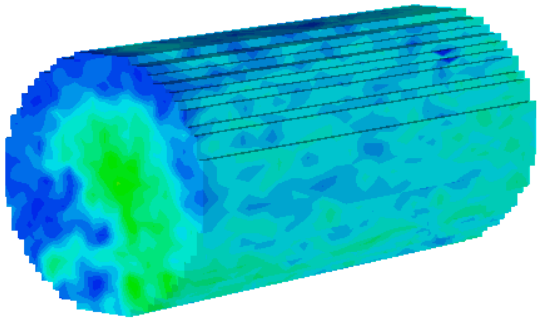
← 2.1 mm →



L. Tomutsa, LBNL

Pore-scale image of CO_2, rock and water

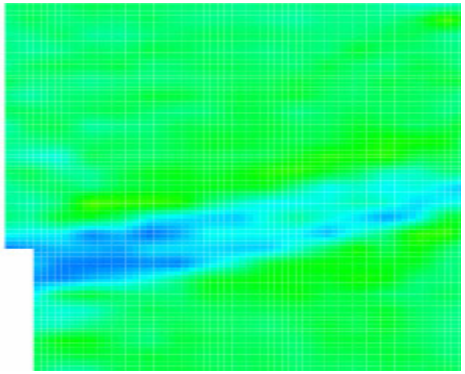
← 7.5 cm →



L. Milkjovic, LBNL

Core-scale image of CO_2 injection into a brine-filled sandstone

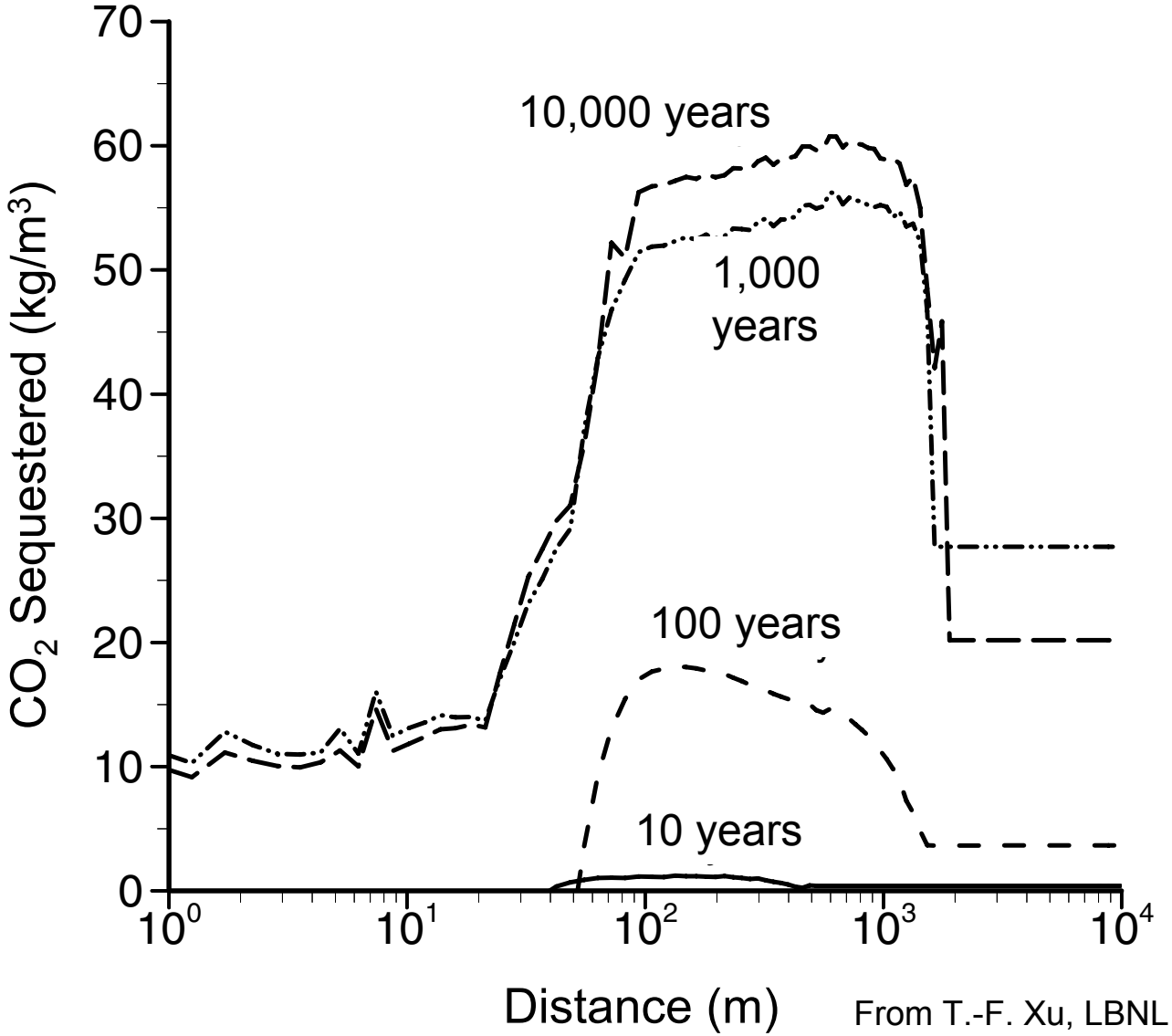
← 30 m →



T. Daley, LBNL

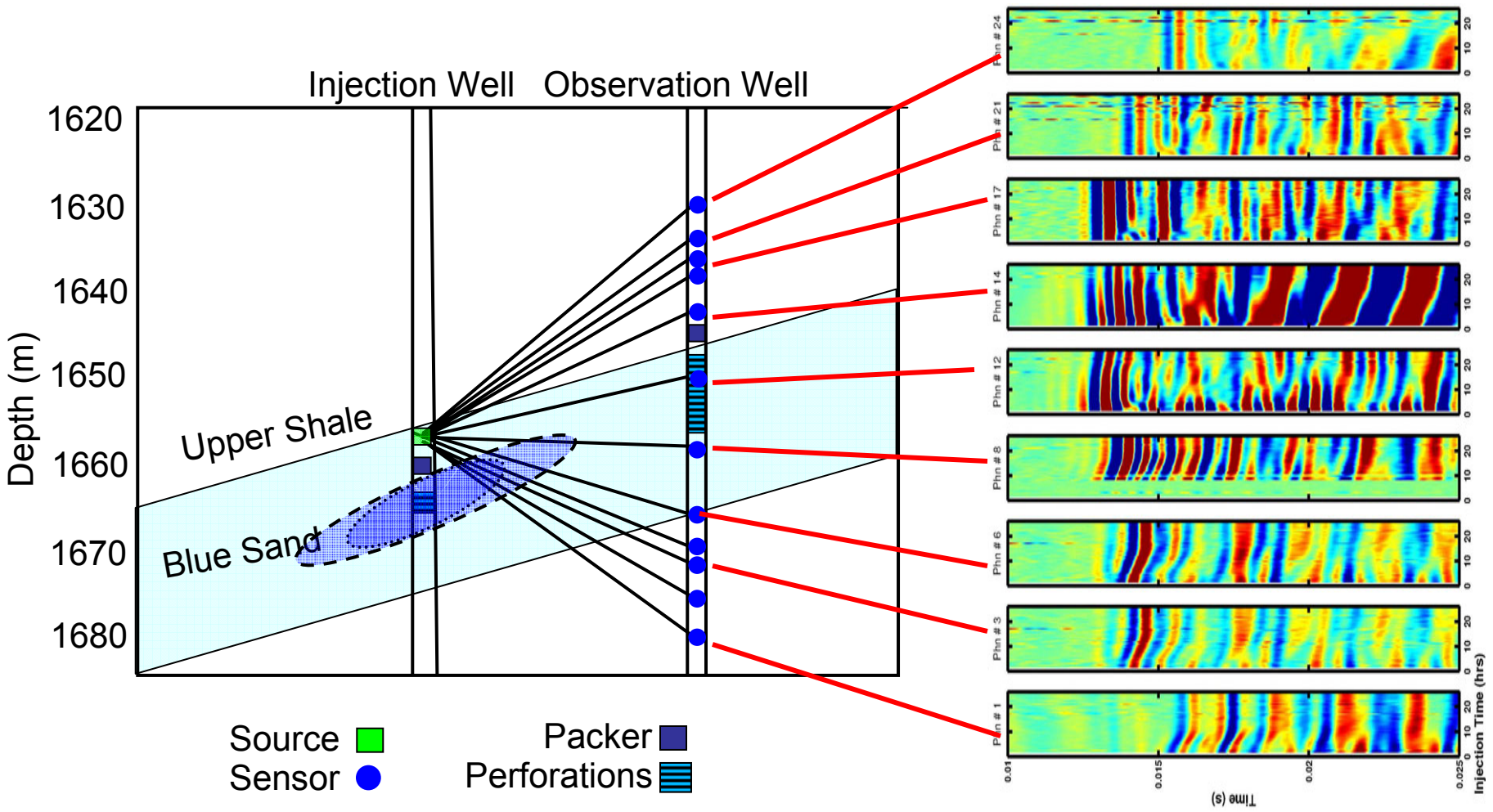
Cross-well seismic image of the CO_2 plume at the Frio Pilot Test Site

Rate of Mineral Trapping



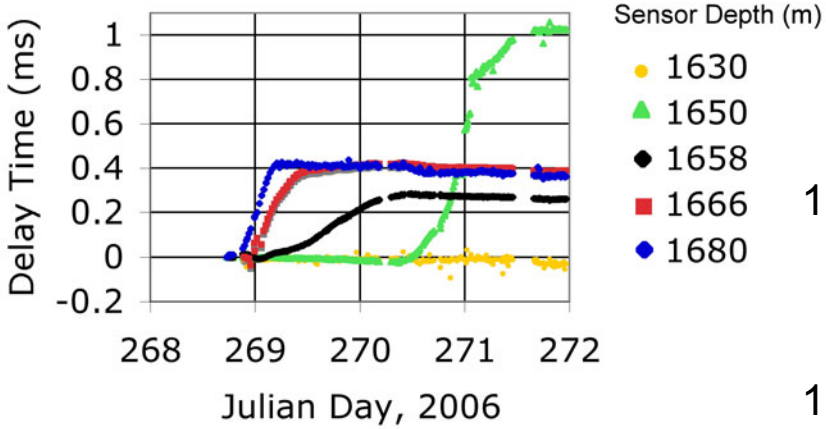
From T.-F. Xu, LBNL

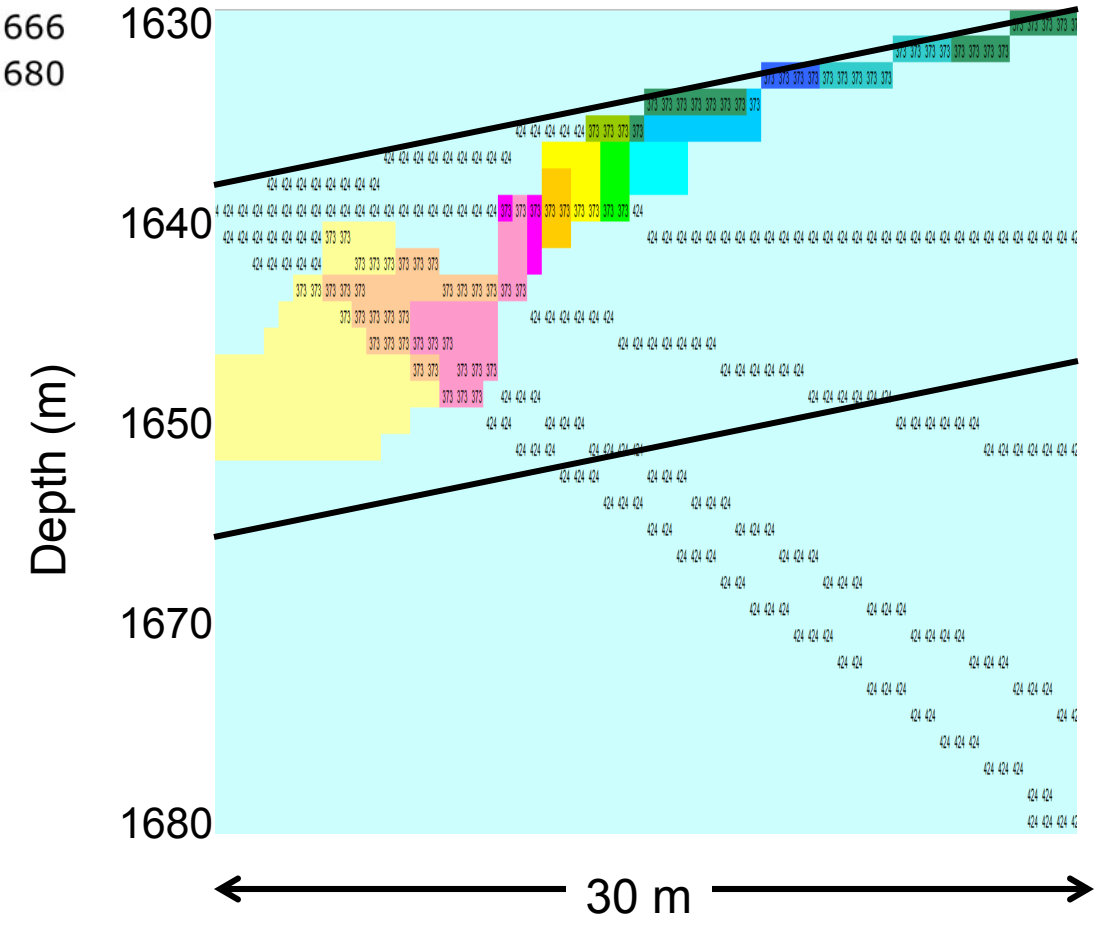
Dynamic Imaging of Complex Multi-Phase Flow



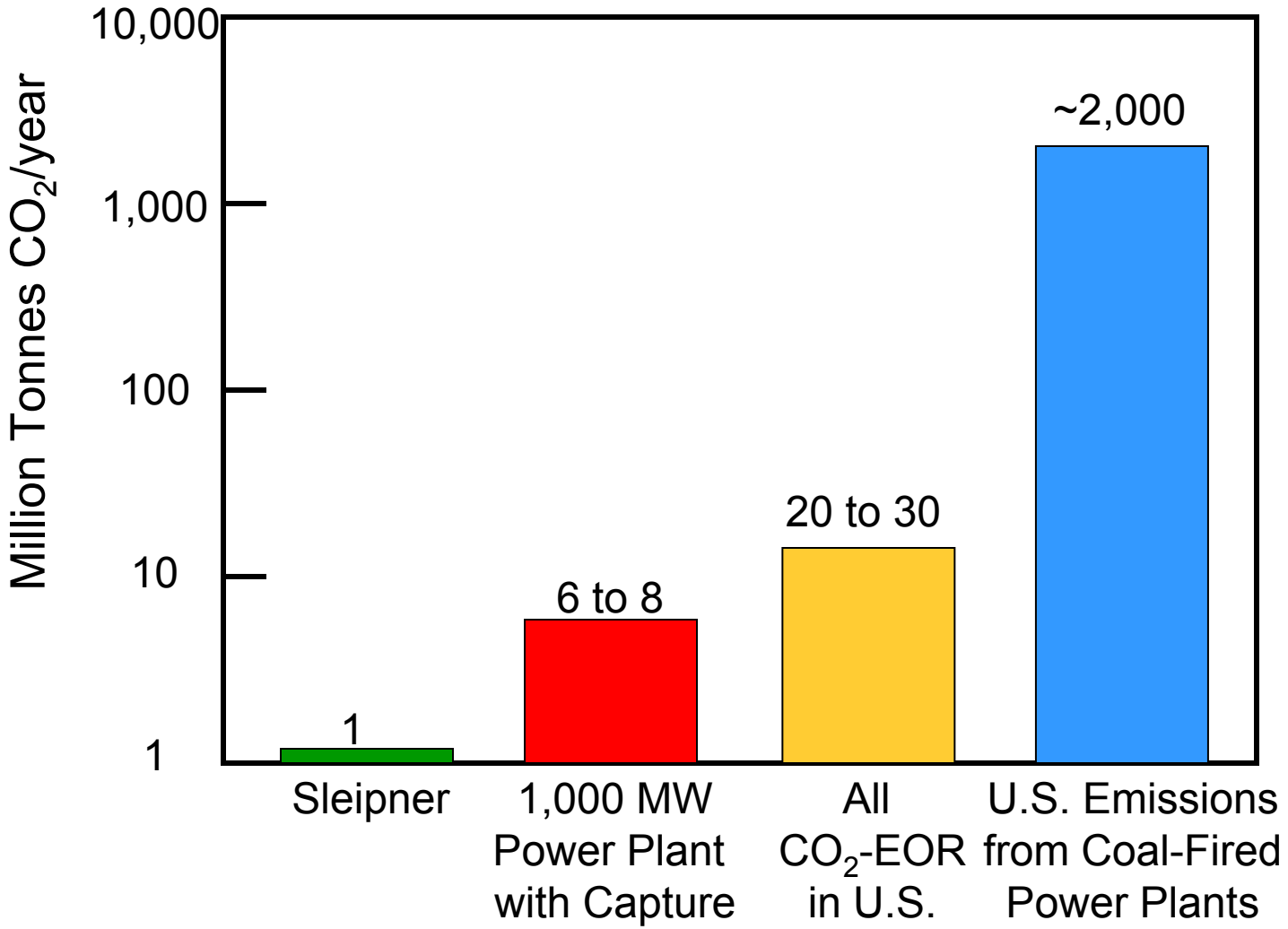
Daley, et al, Geophysics, LBNL, in press.

Real-Time Monitoring of Plume Migration





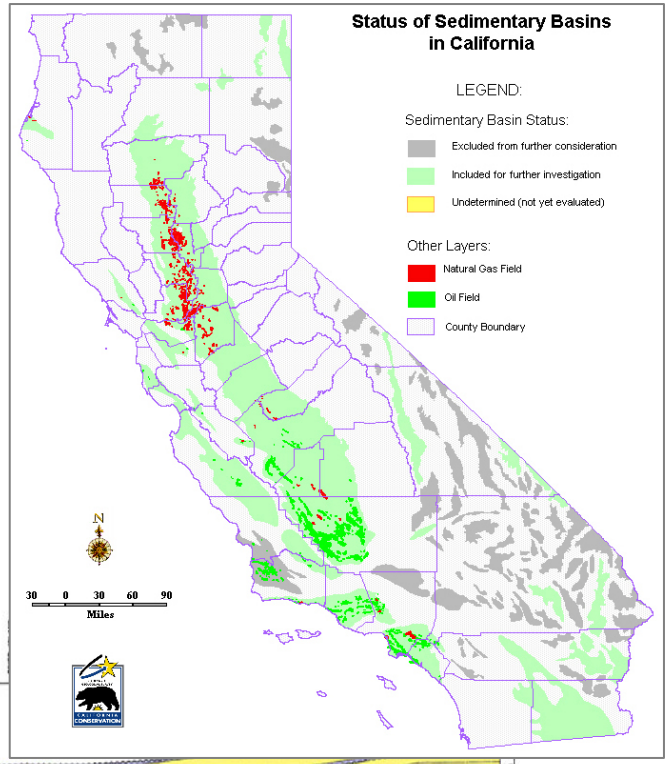
Geomechanical and Hydrological Effects of Large Anthropogenic Perturbations

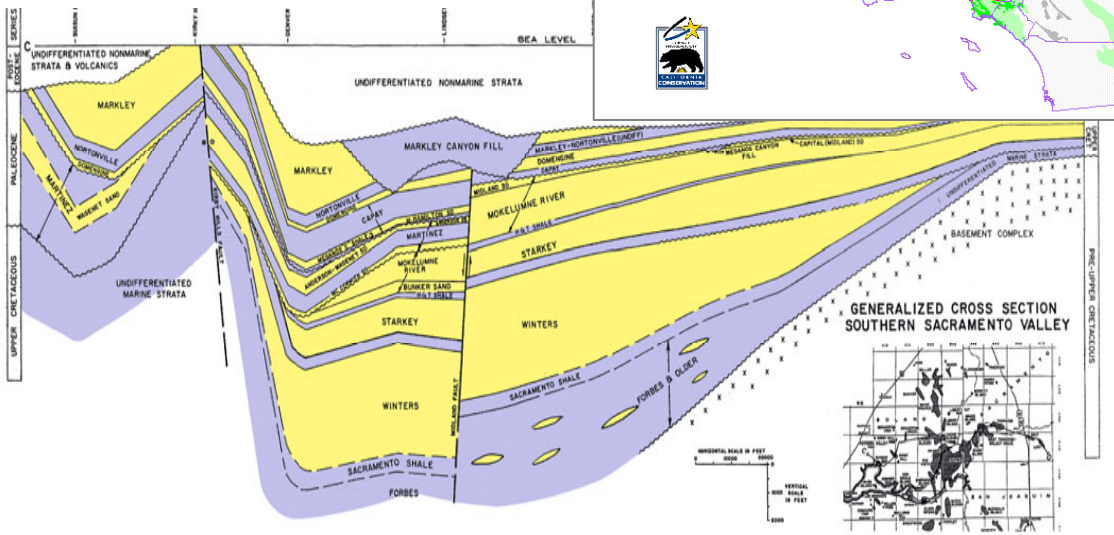


Flow and Transport Properties of Seals, Faults and Fractures

- Are the seals continuous over the storage reservoir?
- What is the 3-D geometry of faults and fractures?
- Are faults seals or fluid conduits?
- How much overpressure can the seals sustain?

75 to 300 billion tonnes storage capacity in saline formations

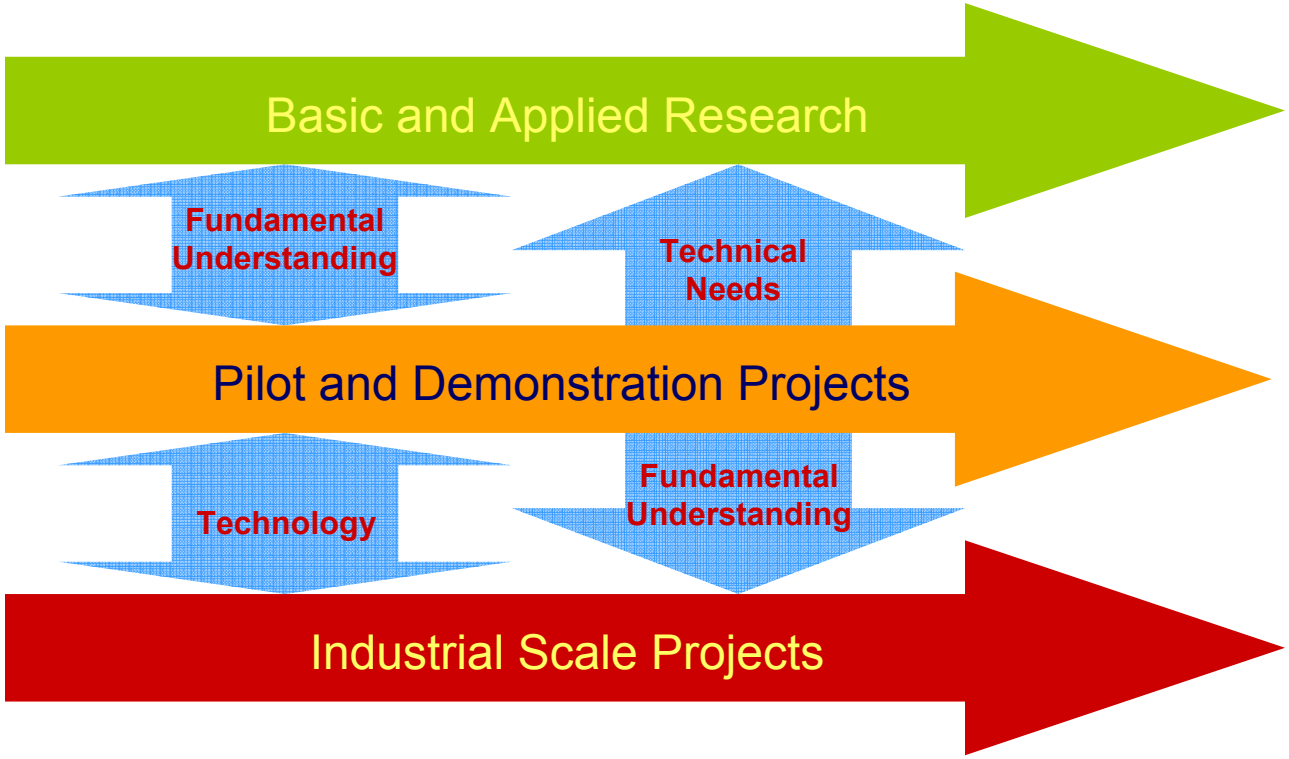




Benefits of Fundamental Research

Influence of heterogeneity at all scales on plume migration	→	Greater confidence in simulation models
Geochemical reactions and kinetics in multi-phase flow systems	→	Greater confidence in mineral trapping
Dynamic imaging of complex multi-phase flows	→	Better quality monitoring
Geomechanical and hydrological effects of large anthropogenic perturbations	→	Better knowledge of CO_2 leakage and brine migration potential
Flow and transport properties of seals, faults and fractures	→	More reliable seal assessment and site selection

Integrated Technology Development Pathway



Ongoing Benefits of Fundamental Research

- Innovation
  - Breakthrough concepts
  - Cost reduction
  - Optimization
- Capacity building
  - Graduate student research
  - Training ground for a pool of qualified professionals
  - Train new generation of research leaders
- Confidence building
  - Cadre of academic, research and industry experts
  - Peer to peer information sharing

DOE Office of Science Sponsored a Workshop on Basic Research Needs in the Geosciences

- Identify use-inspired and fundamental research needs in the geosciences
- Topics
  - Multi-Phase Flow
  - Reactive Chemical Transport
  - Simulation
  - Characterization
- Report will come out in June, 2007
- http://www.sc.doe.gov/bes/reports/list.html

All of these topics are relevant to geological storage of CO_2.

Multi-phase Flow Workshop Participants

*Sally Benson, Stanford
Steven Bryant, UT Austin
Robert Burruss, USGS
*Michael Celia, Princeton
Charles Christopher, BP
David Cole, ORNL
Jerry Harris, Stanford
Susan Hovorka, UT Austin
James Johnson, LLNL
Yousif Kharaka, USGS
Peter Lichtner, LANL
Erik Lindeberg, Sintef
Pete (B.P.) McGrail, PNNL
Curt Oldenburg, LBNL
Tullis Onstott, Princeton
Daniel Schrag, Harvard
Teng-fong Wong, SUNY

*Co-chairs