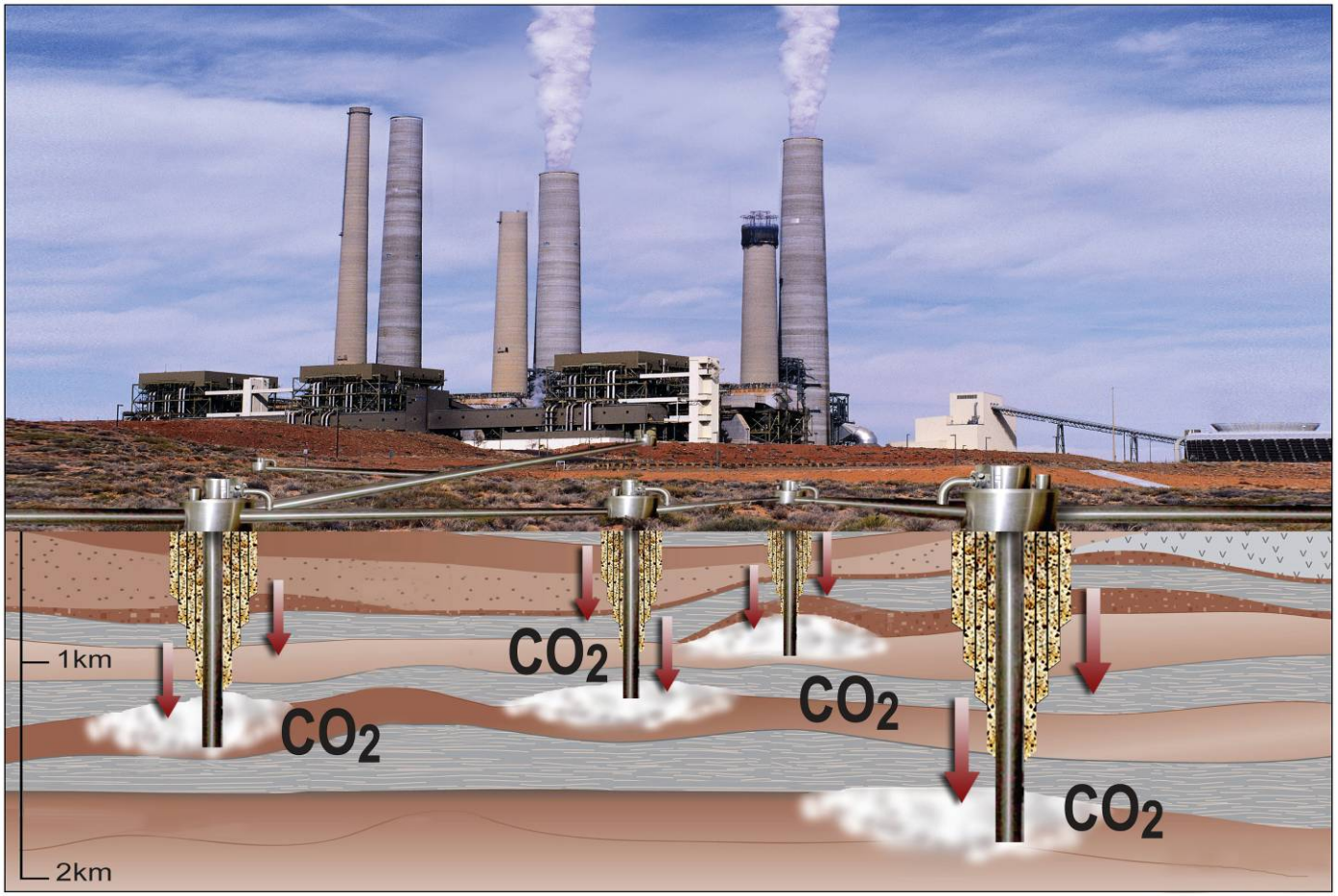
GCEP

AGU Annual Meeting
December 19, 2008

What Does a CO_2 Plume Look Like: Implications for Geophysical Monitoring

Sally M. Benson
Energy Resources Engineering Department
Executive Director, Global Climate and Energy Project
Stanford University

Carbon Dioxide Capture and Geologic Storage is one Way to Reduce Emissions



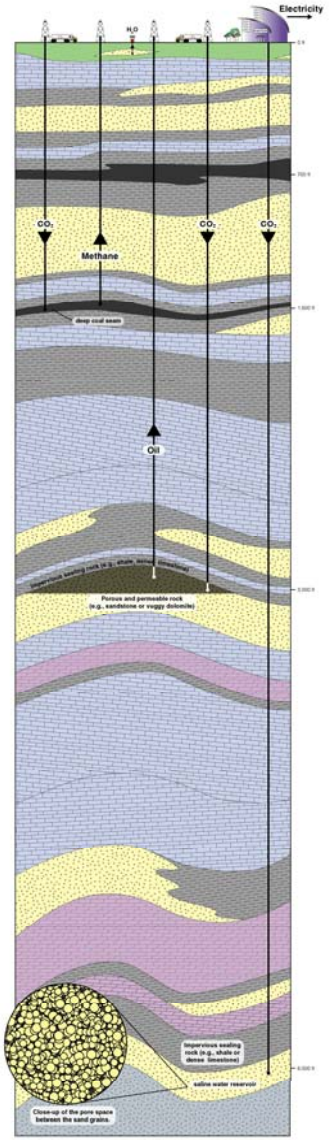
Capture → **Compression** → **Pipeline Transport** → **Underground Injection**

Some Key Questions

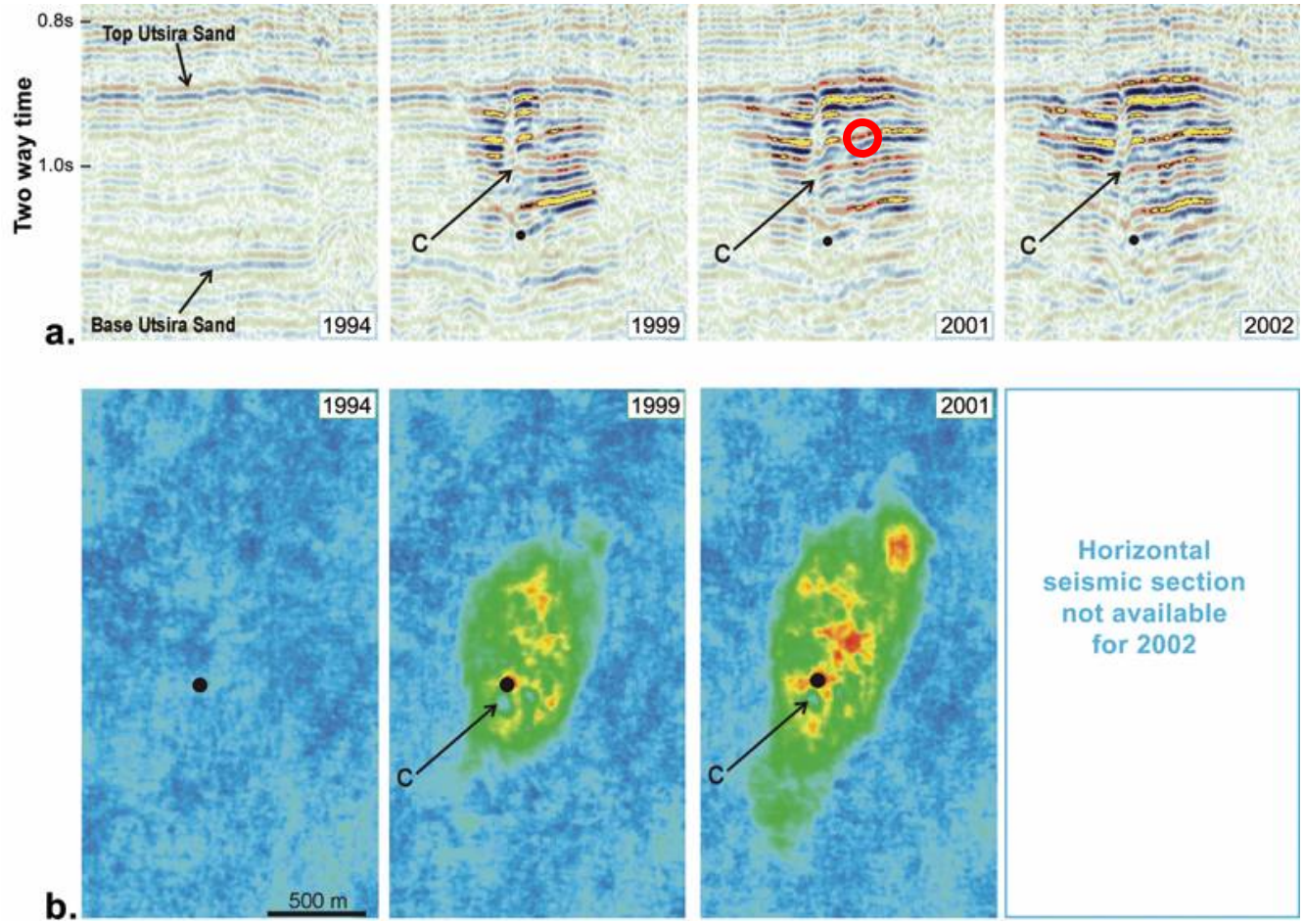
- What fraction of the pore space is used for CO_2 storage?
- How far has the CO_2 move from the injection site?
- Has CO_2 leaked out of the storage reservoir?

- Geophysical monitoring is the primary tool used to answer these questions

So, what does a CO_2 plume look like?

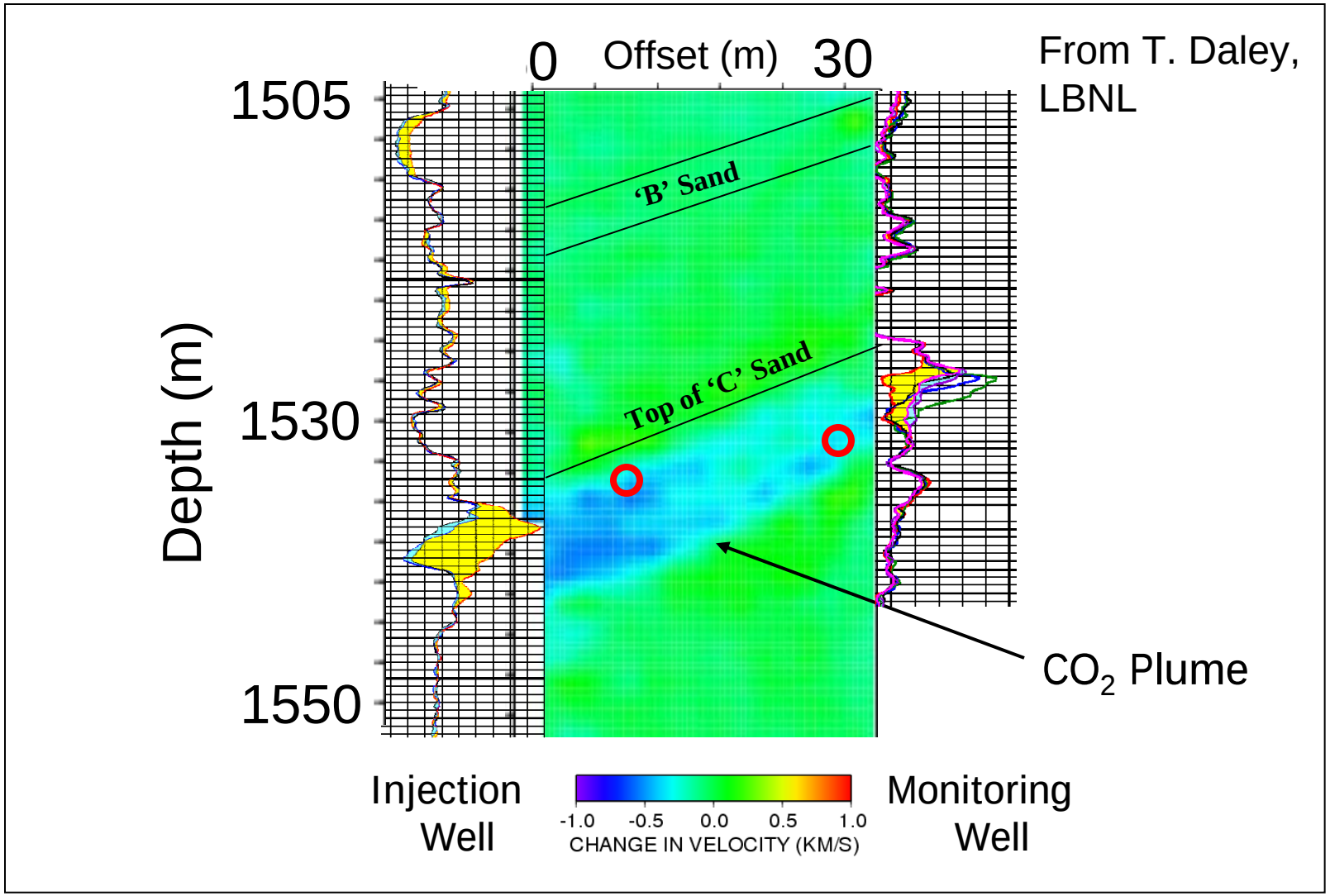


Examples: Seismic Data Collected at Sleipner

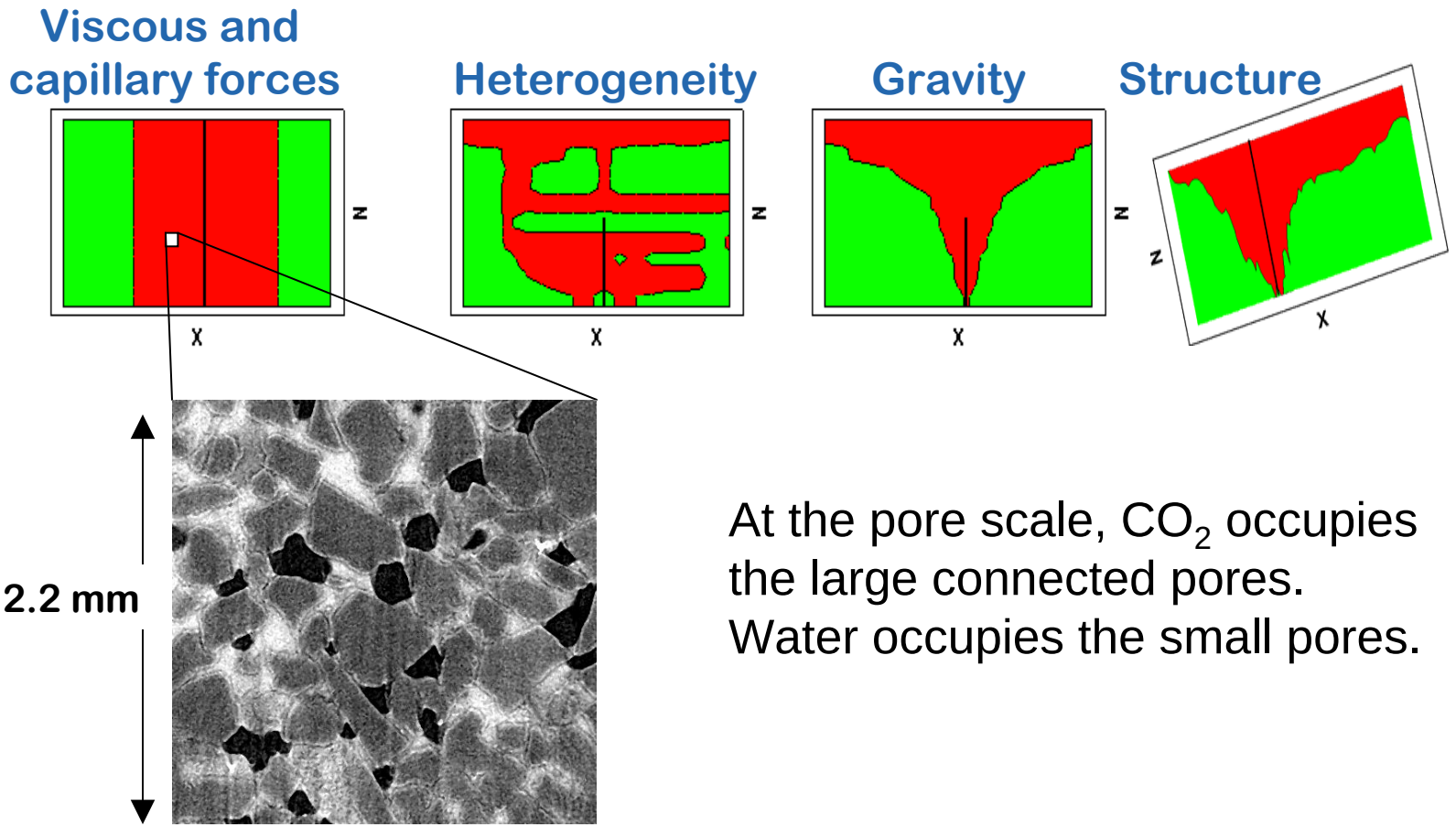


From IPCC, 2005, after Chadwick, 2004

Frio Formation
Cross-well Seismic Data



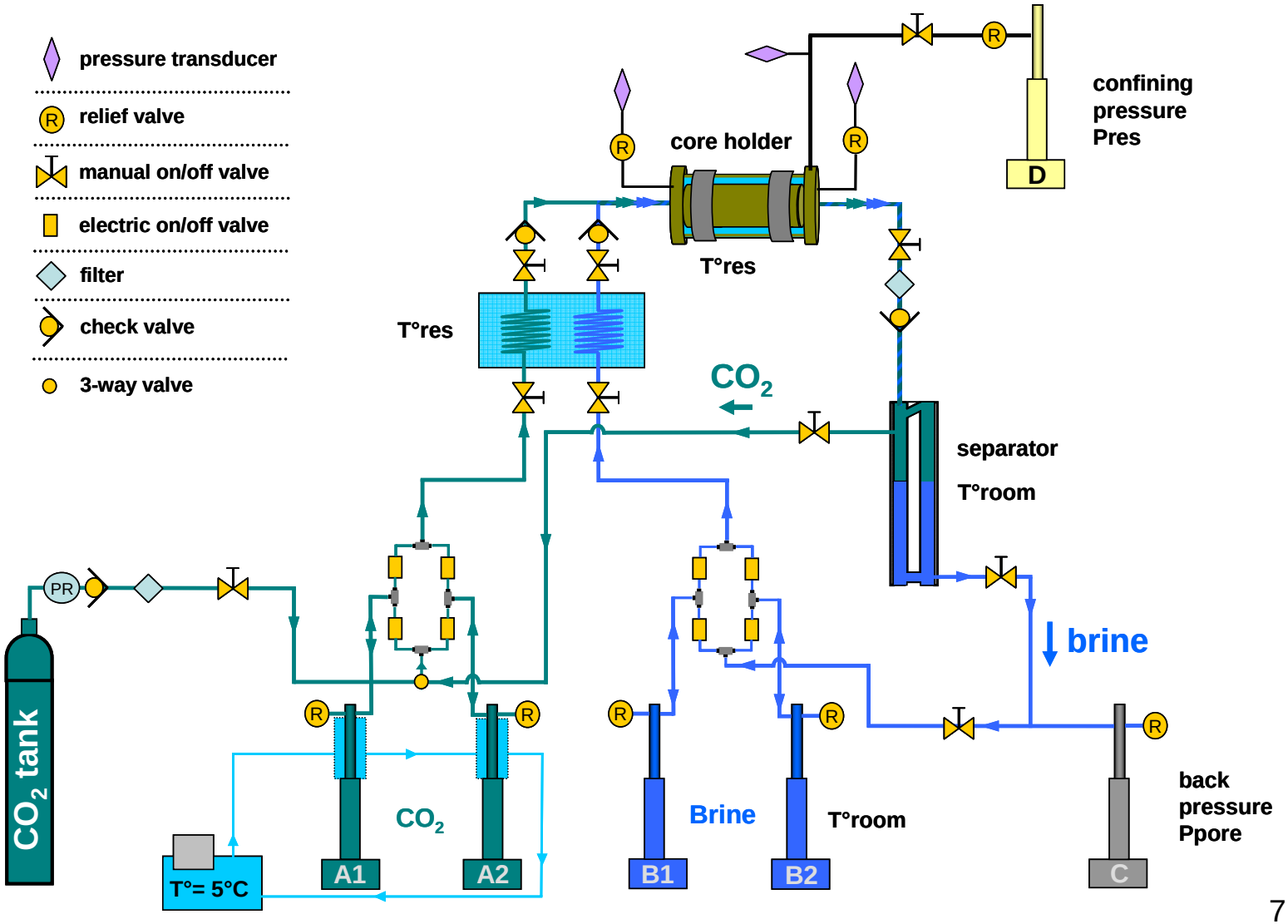
Multi-Phase Flow Dynamics
Key to "What a Plume Looks Like"



At the pore scale, CO_2 occupies the large connected pores. Water occupies the small pores.

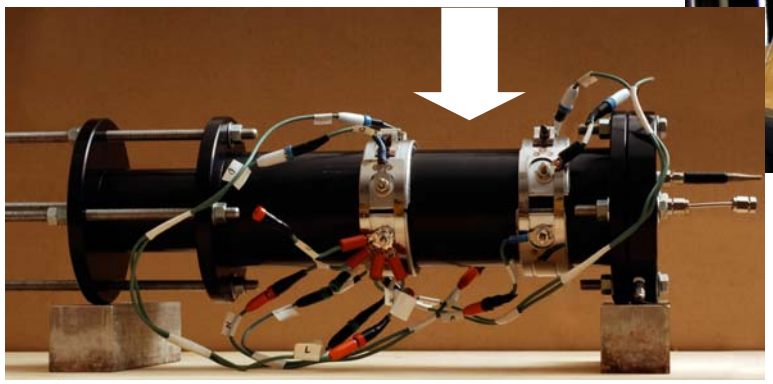
Micro-tomogram of a CO_2 and water-filled rock: From L. Tomutsa, LBNL

Schematic of Multi-Phase Flow Apparatus

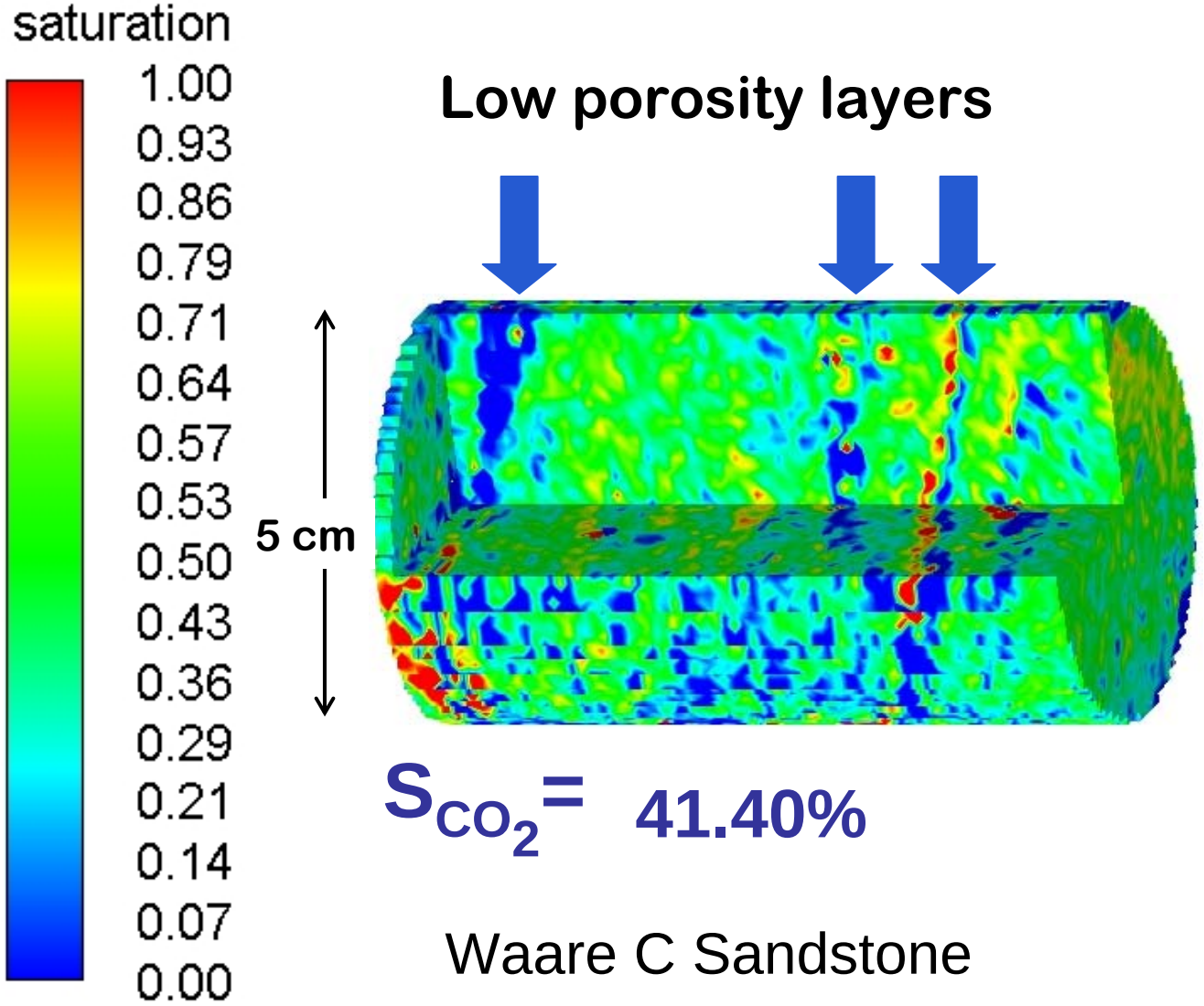


Multi-Phase Flow Laboratory

Replicate *in situ* conditions
- Pressure
- Temperature
- Brine composition

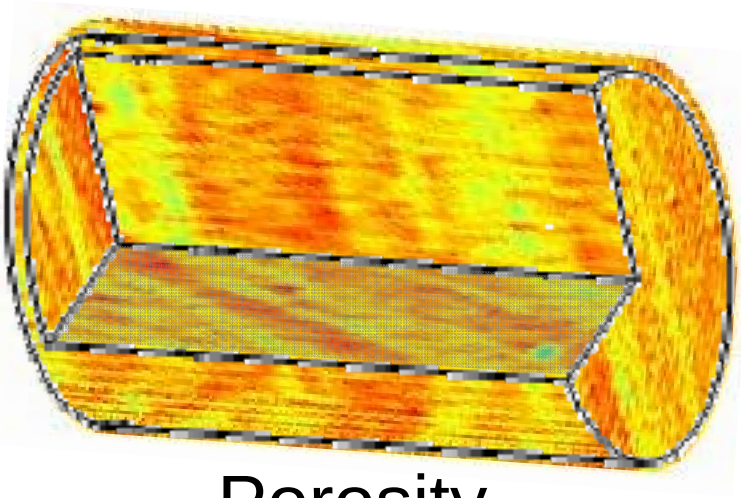


Influence of Rock Heterogeneity



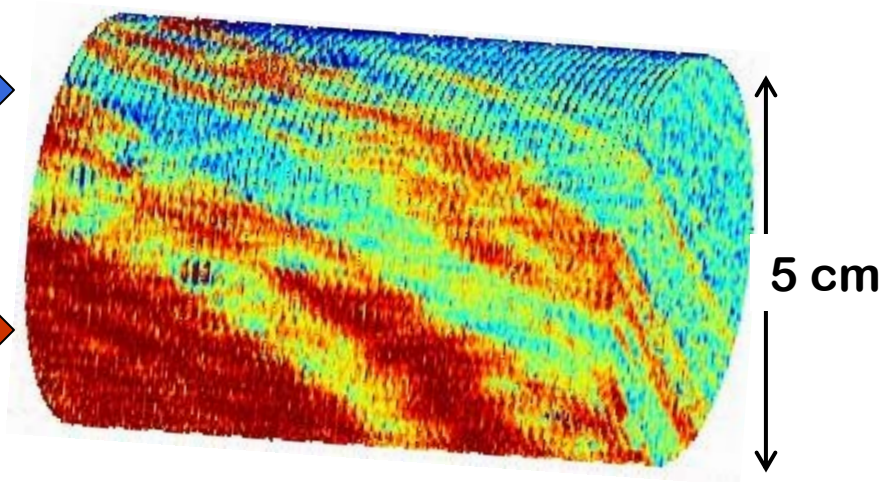
Low porosity layers have low CO_2 saturations

Influence of Heterogeneity and Structure



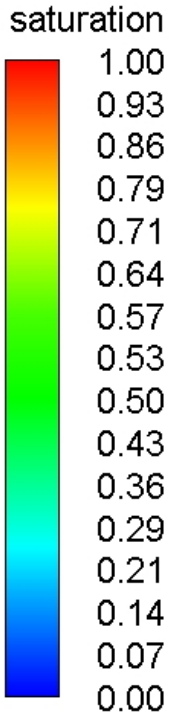
Porosity

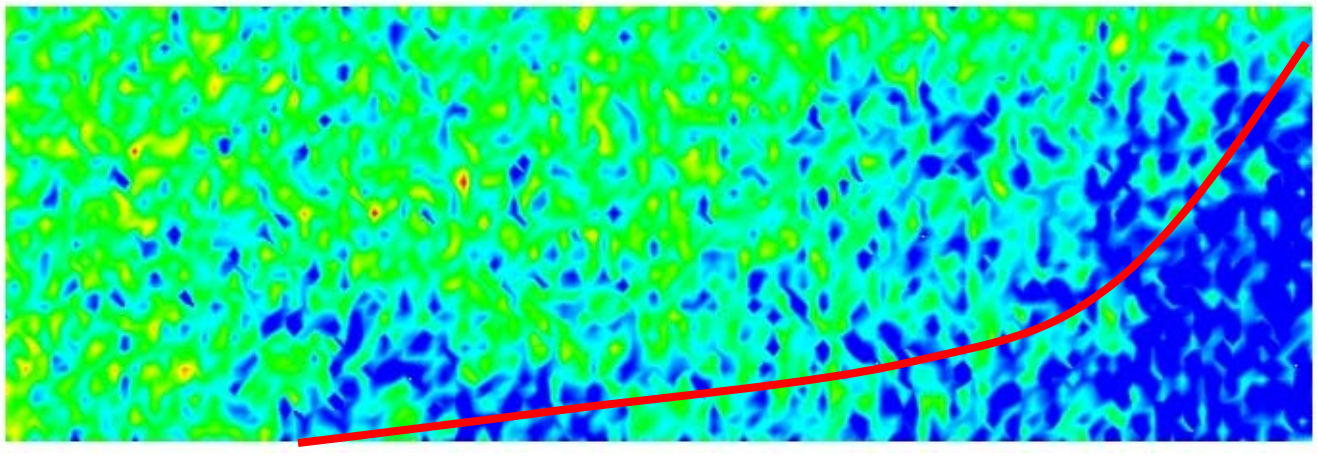
Low porosity units act as capillary barriers diverting CO_2 to the top of the core.



CO_2 Saturation

Influence of Gravity





S_{CO_2}= 31.46%

In "homogeneous cores", gravity override diverts CO_2 to the top of the core, leaving the lower portions water saturated.

Berea sandstone – "Homogeneous"

Implications for Geophysical Modeling

- CO_2 saturations are variable at a hierarchy of spatial scales, from the pore scale to field scale
- CO_2 saturations are lower than expected when gravity override and heterogeneity are neglected
- Core-scale studies can elucidate primary factors that control small scale variations (10's of cm)
- Conceptual models capturing realistic variability can be developed based on measurements and modeling at a hierarchy of scales