

# The Impact of Small-Scale Heterogeneities on Residual Trapping: Case Study from the Otway CO<sub>2</sub> Storage Site

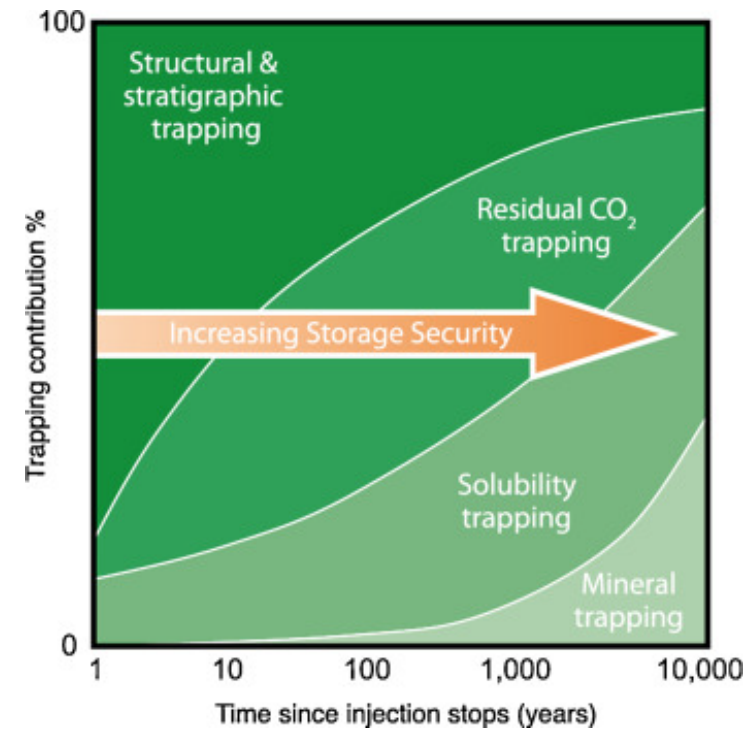
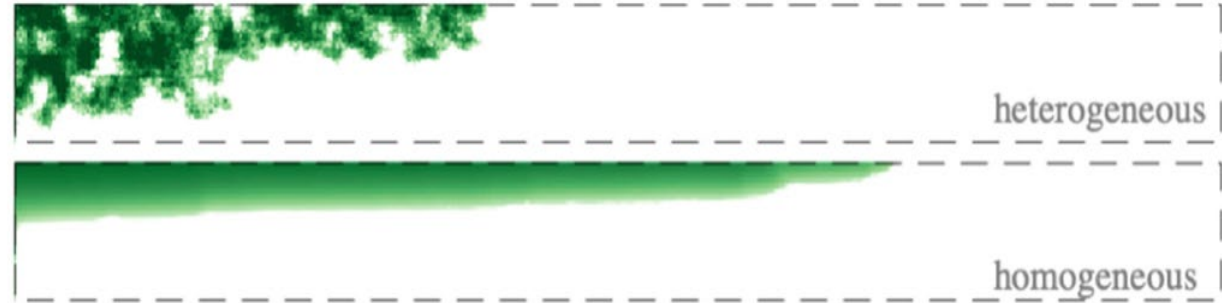
**Catherine Spurin, Catherine Callas, Mitch Allison, David Bason, and Sally Benson**



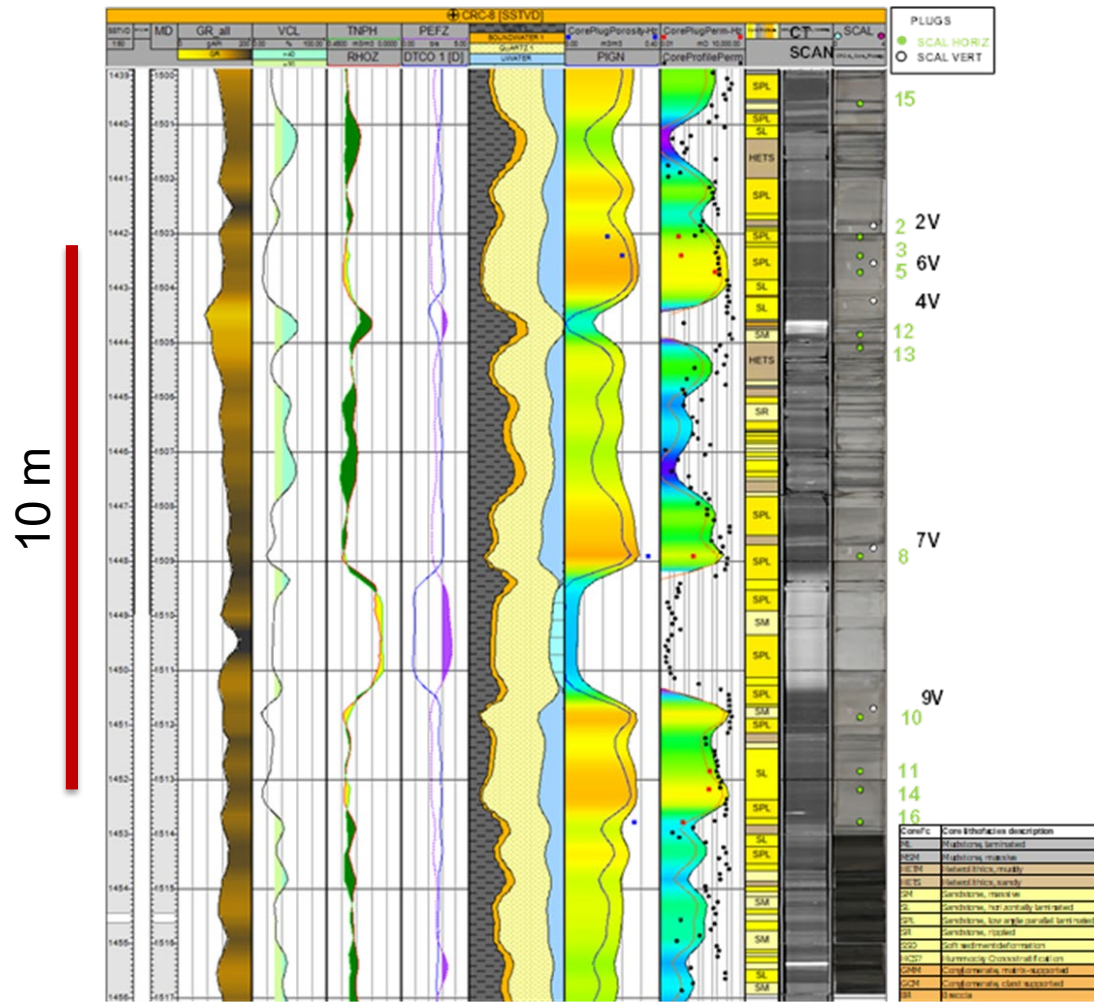
Stanford | Doerr | Stanford Center  
School of Sustainability | for Carbon Storage

# The importance of small-scale heterogeneities

- Heterogeneity affects CO<sub>2</sub> spread and trapping.
- Small-scale heterogeneities influence the movement of CO<sub>2</sub>, heavily influencing residual trapping
- Currently this influence is not represented in reservoir models



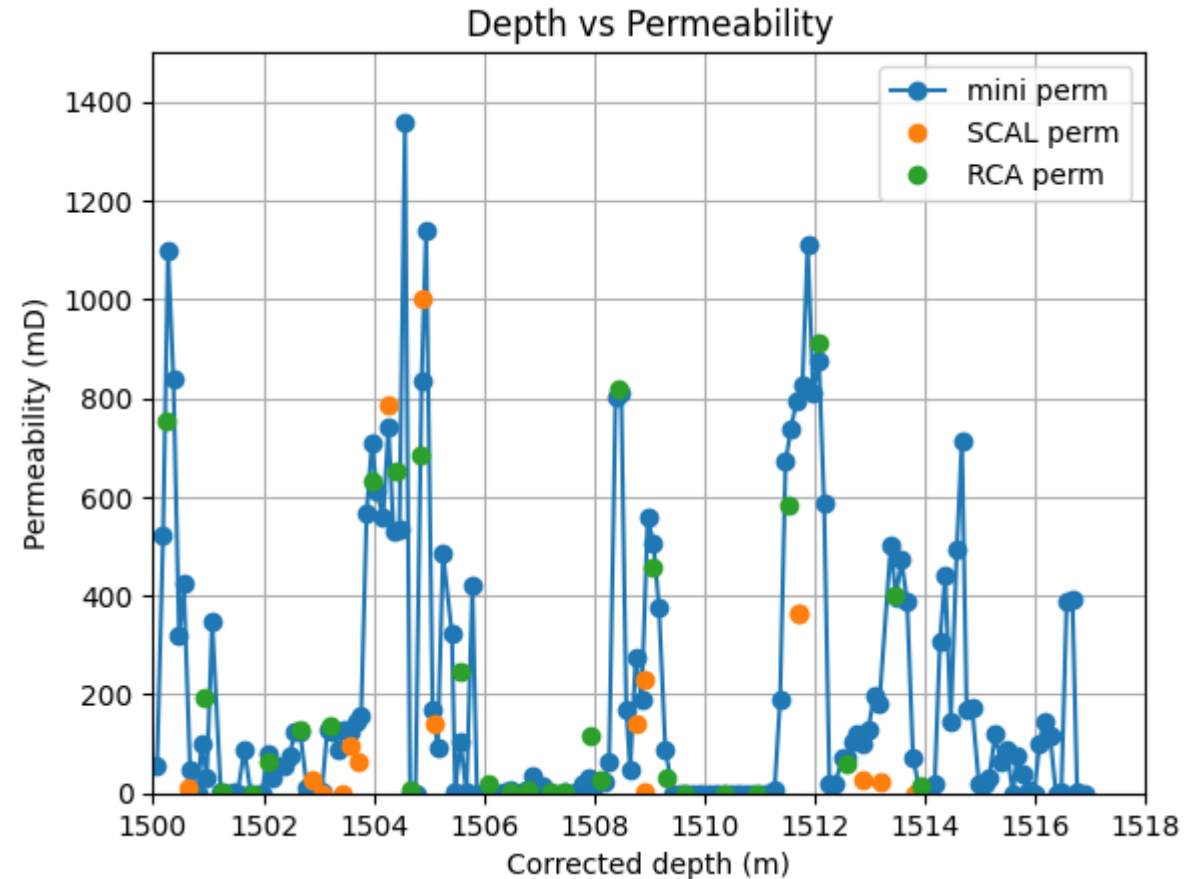
# Sampling a wide range of heterogeneities at Otway



- 10 samples over a range of ~ 15 m
- Samples 5 cm diameter, 5-10 cm length
- Experiments performed at high pressure (8 MPa) and high temperature (50 °C)
- High resolution reservoir models = 0.3 m

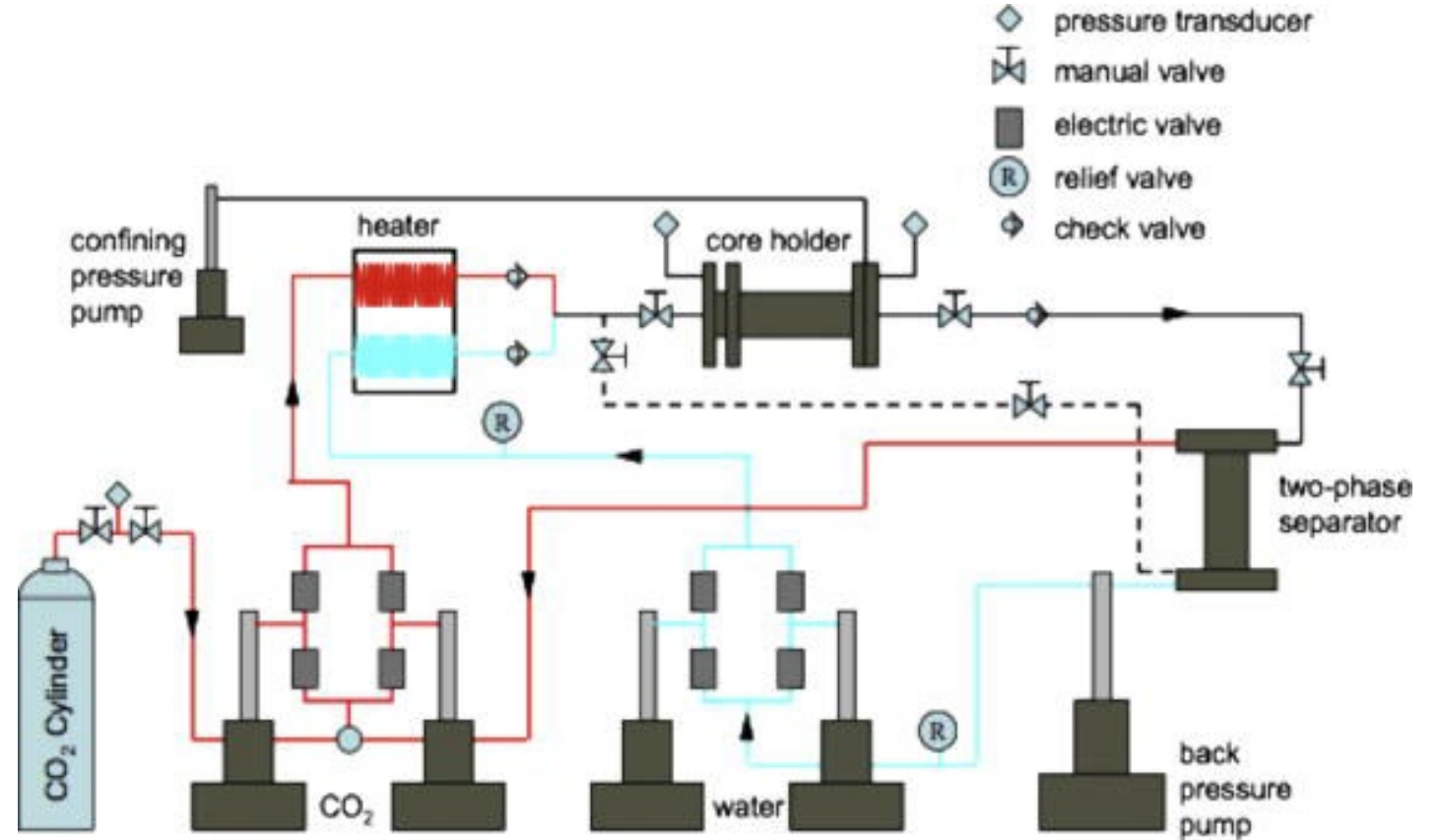
# Large permeability variations highlight heterogeneity

- Some variation in permeability between different types of measurements
- This is due to the length over which the measurement is made



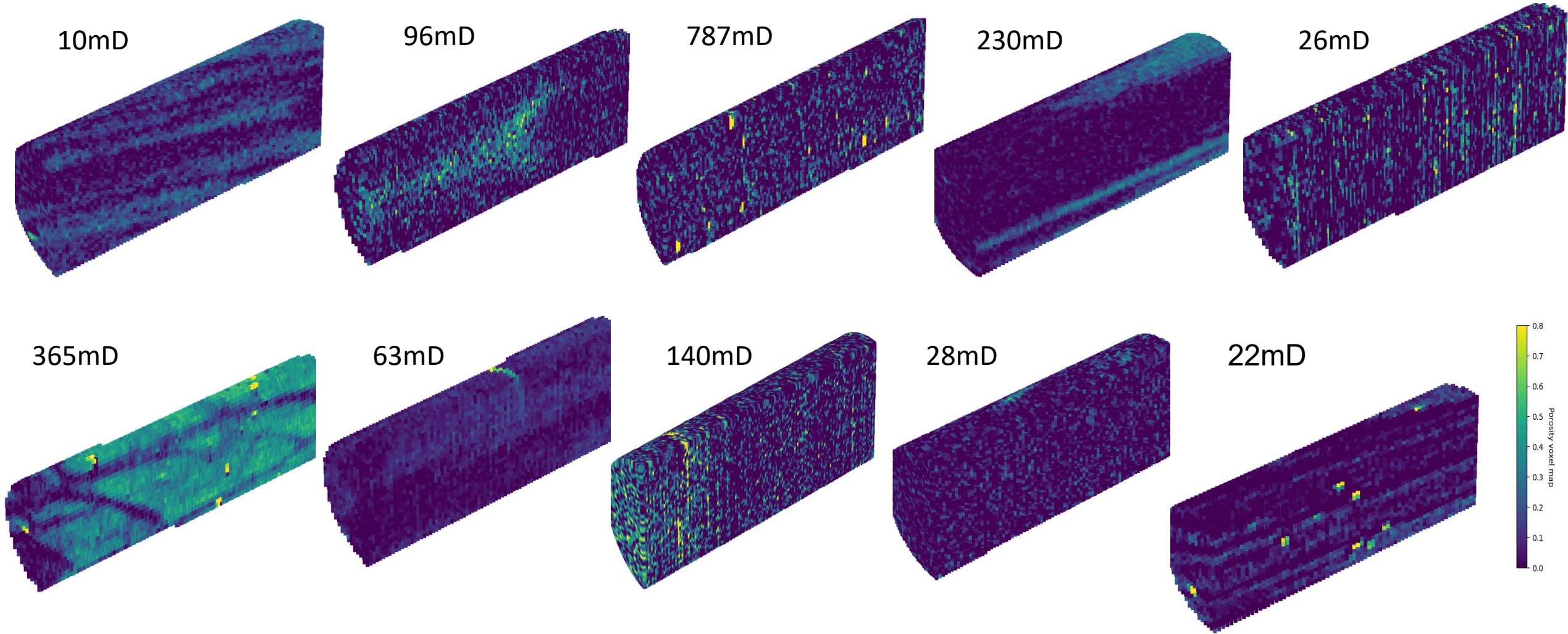
# Multiphase flow experiments

- Sample saturated with CO<sub>2</sub> saturated water
- CO<sub>2</sub> saturated water and CO<sub>2</sub> co-injected as a range of fractional flows
- Pressure drop measured across core
- Saturation measured with medical CT scanner (resolution ~0.5 mm)

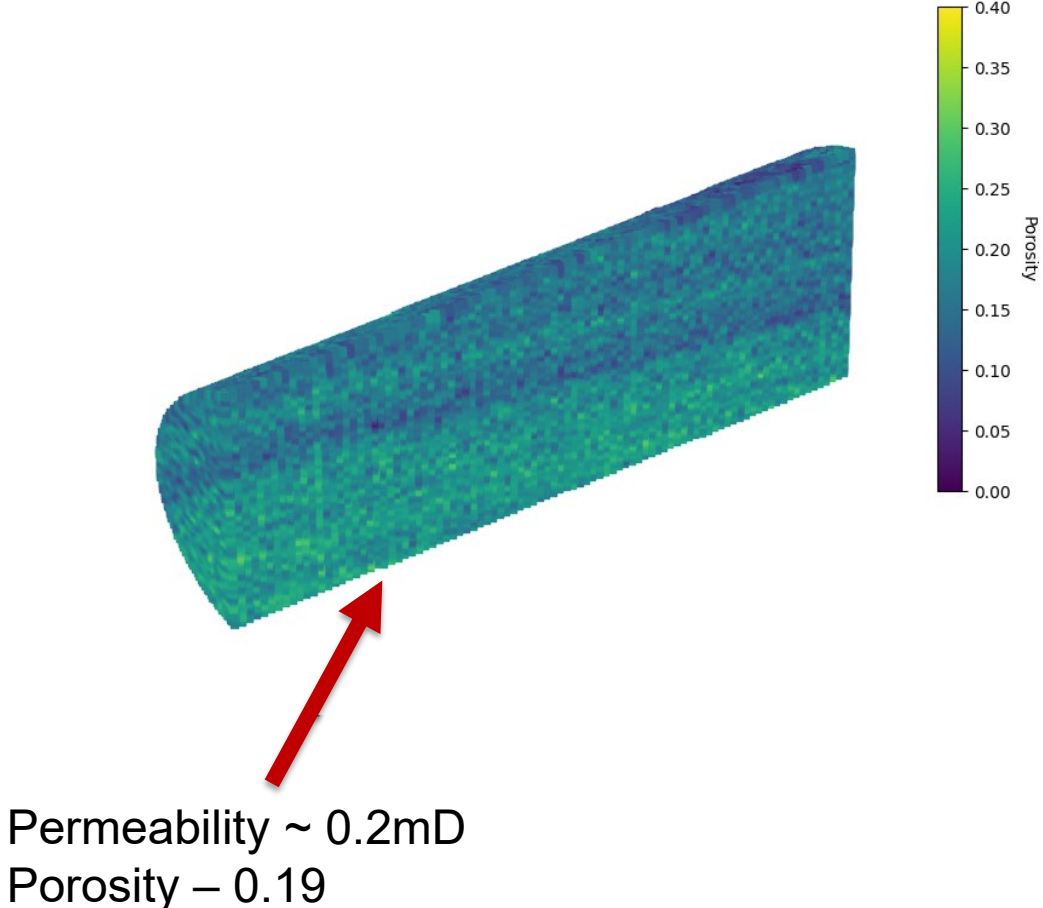
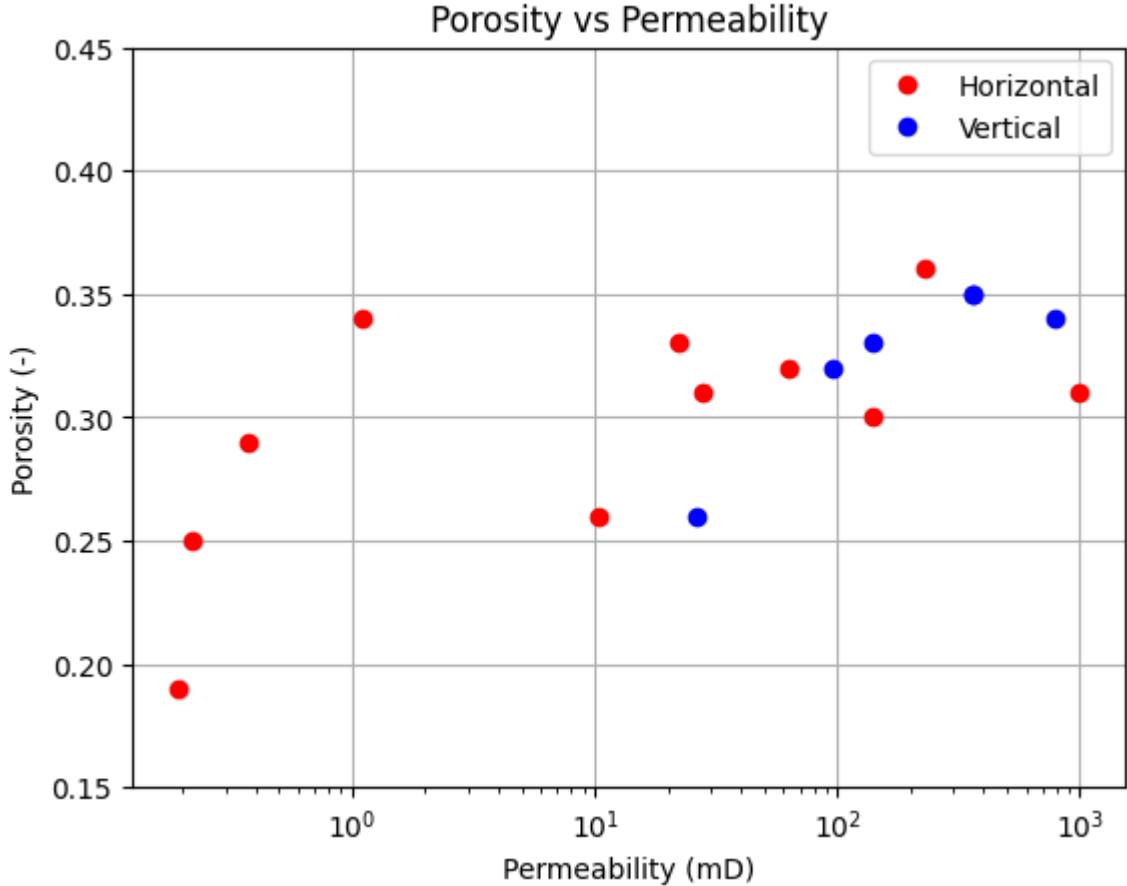




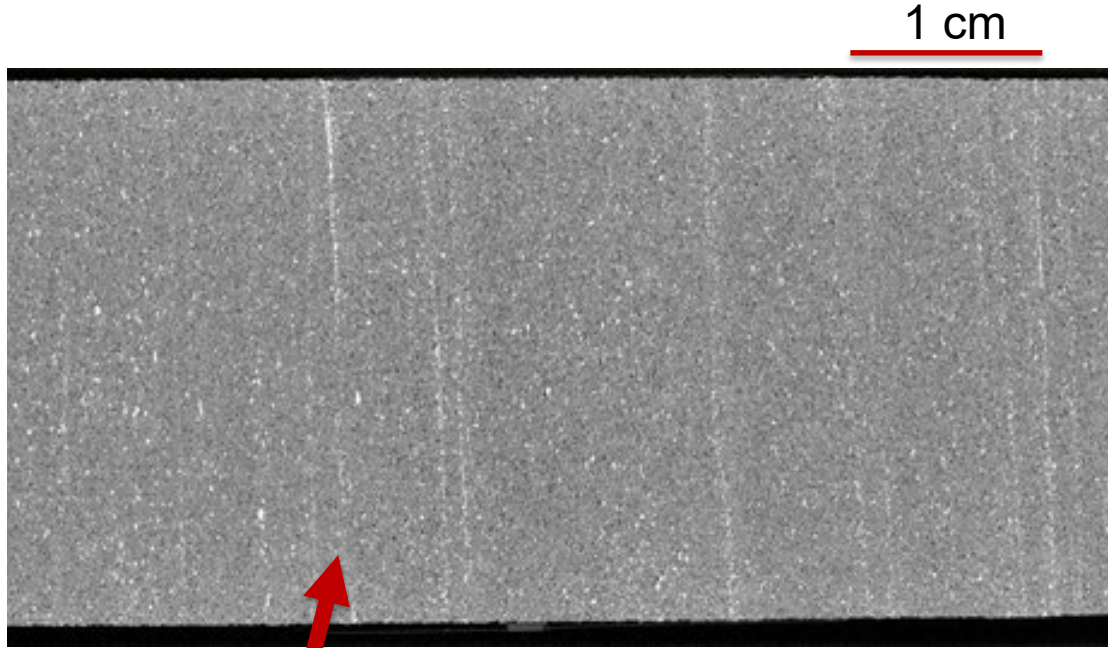
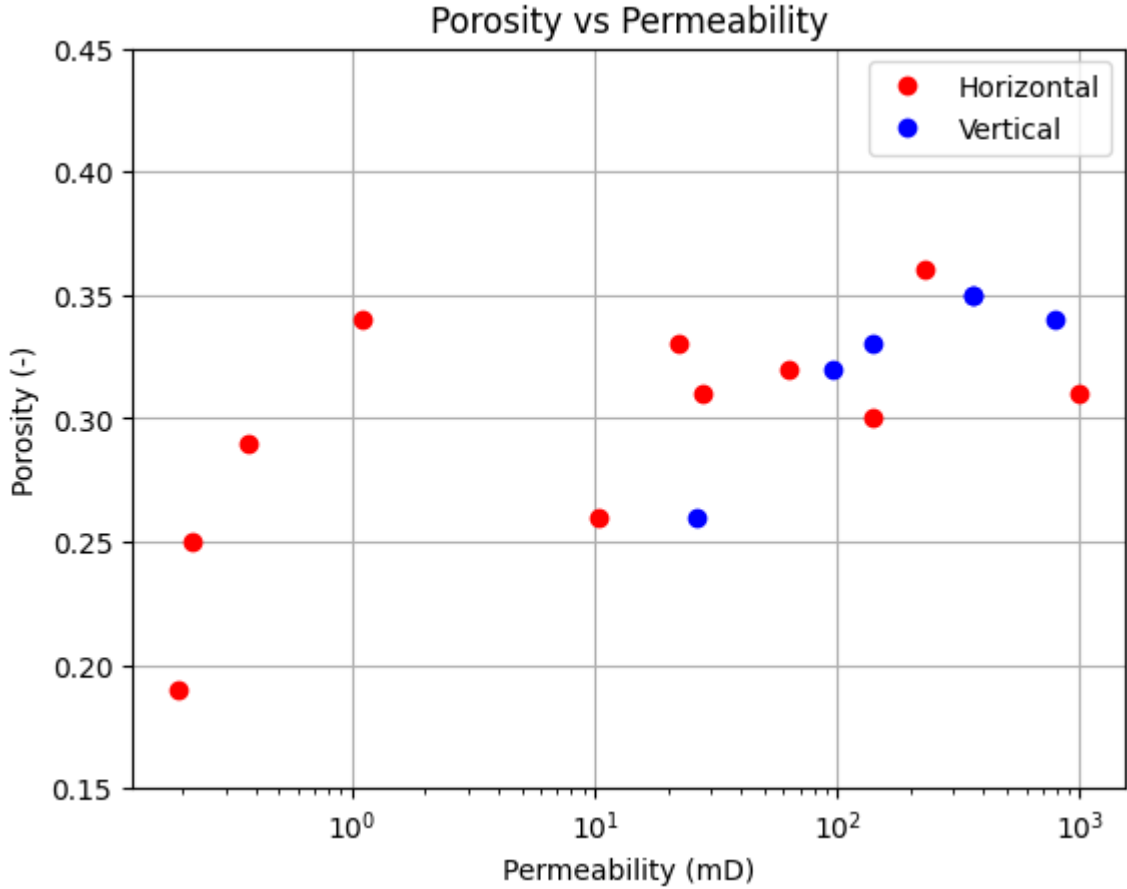
# Range of heterogeneities seen in experiments



# Large variations in permeability even with narrow range of porosity



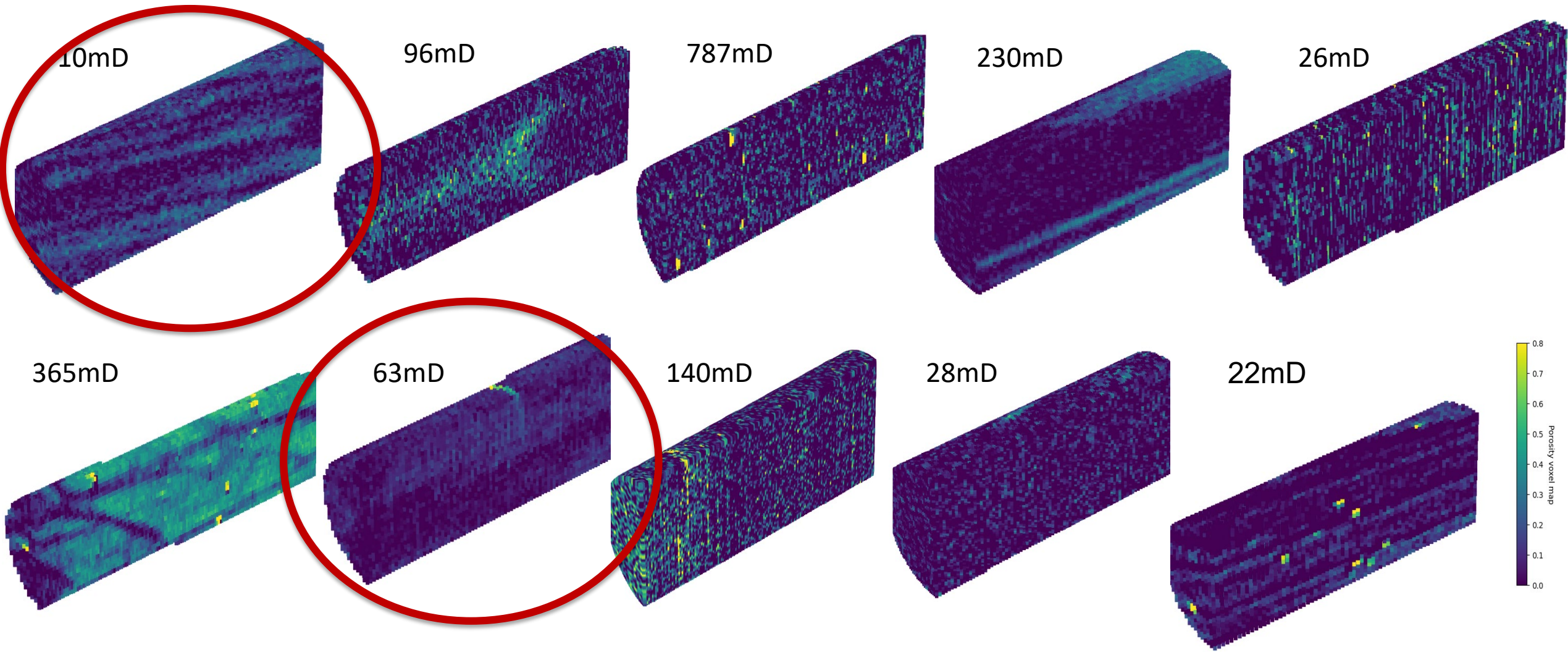
# Large variations in permeability even with narrow range of porosity



Some features below the image resolution of the medical CT scanner (~0.5mm)

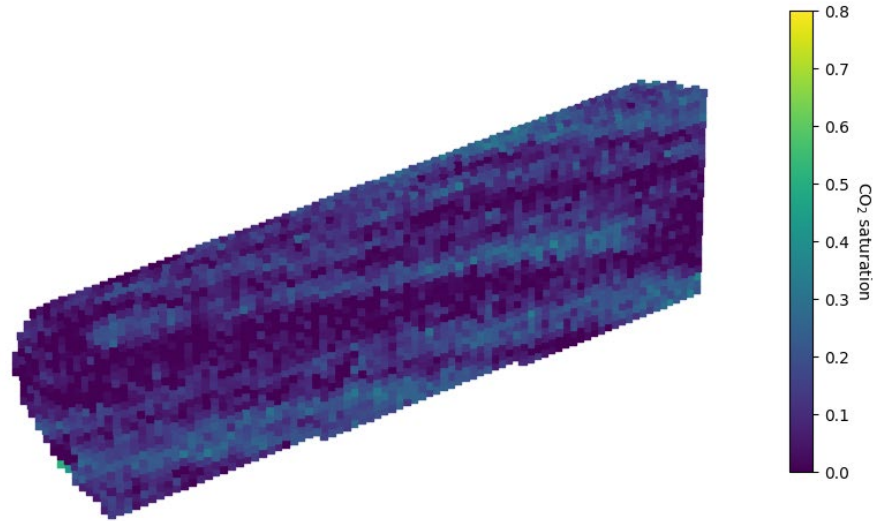


# Range of heterogeneities seen in experiments

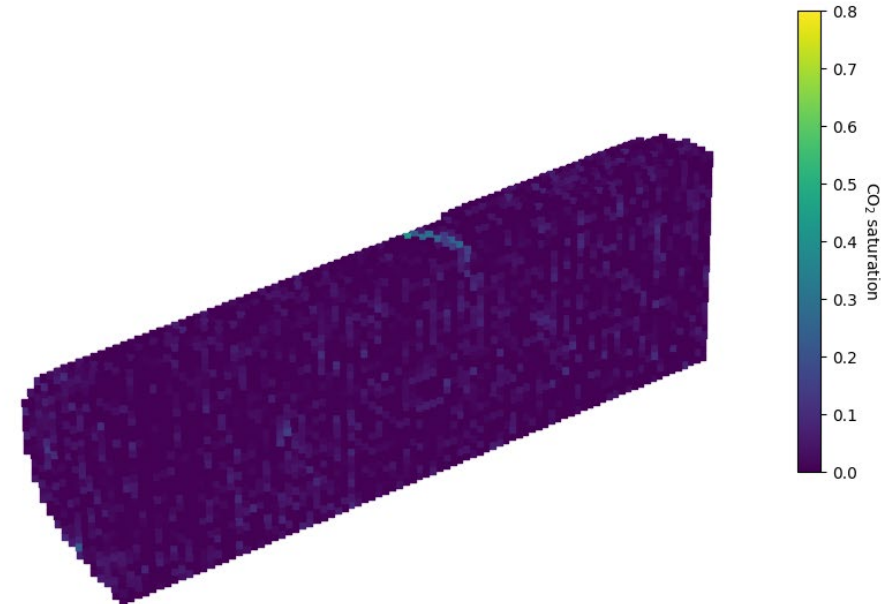


# Influence of small-scale heterogeneity on CO<sub>2</sub> movement

Samples from same facies, taken 3 m apart:

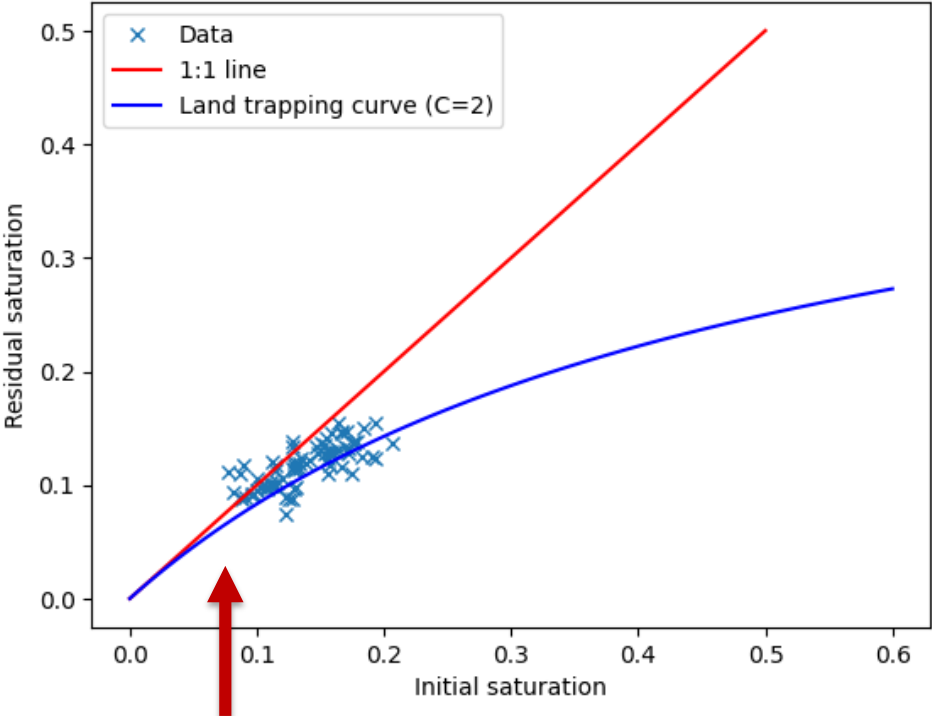
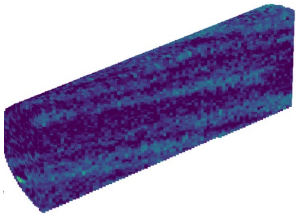


10mD,  $\phi = 0.26$

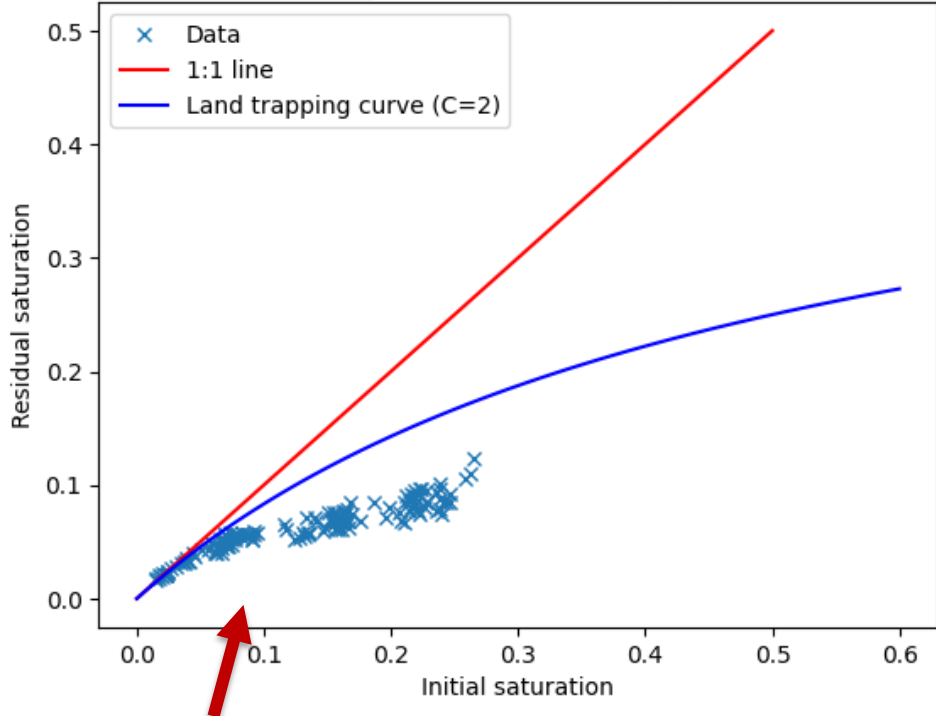
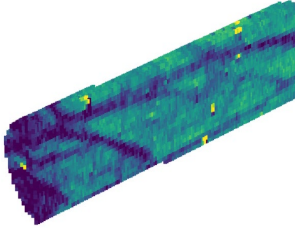


63mD,  $\phi = 0.32$

# Impact of heterogeneity on trapping efficiency

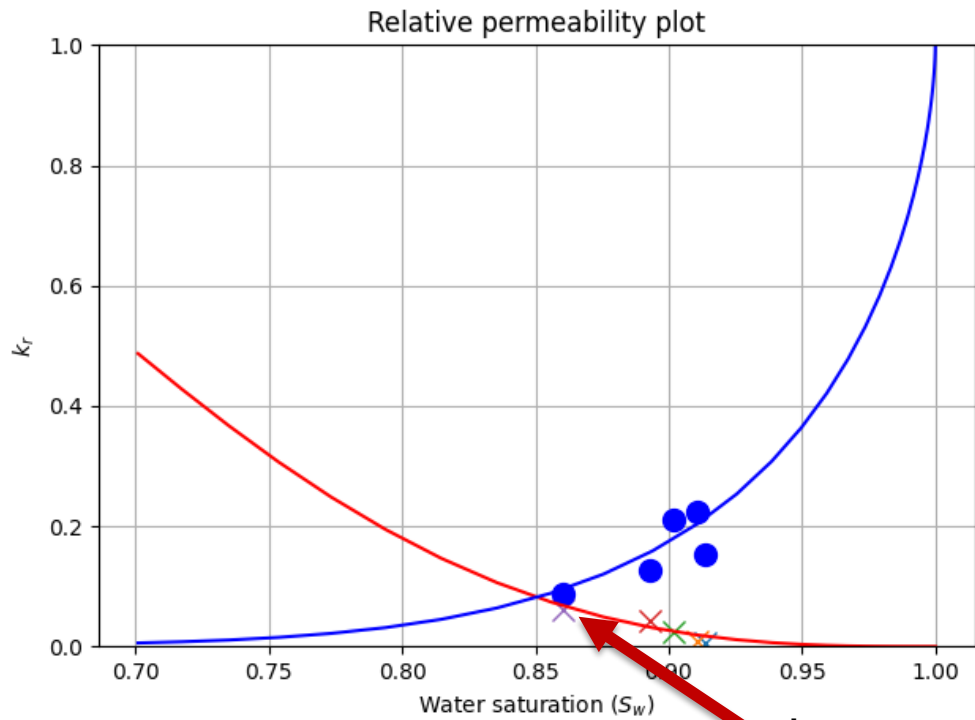
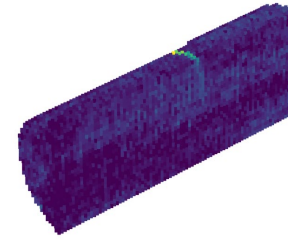
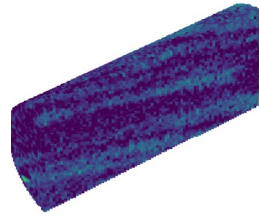


Great trapping

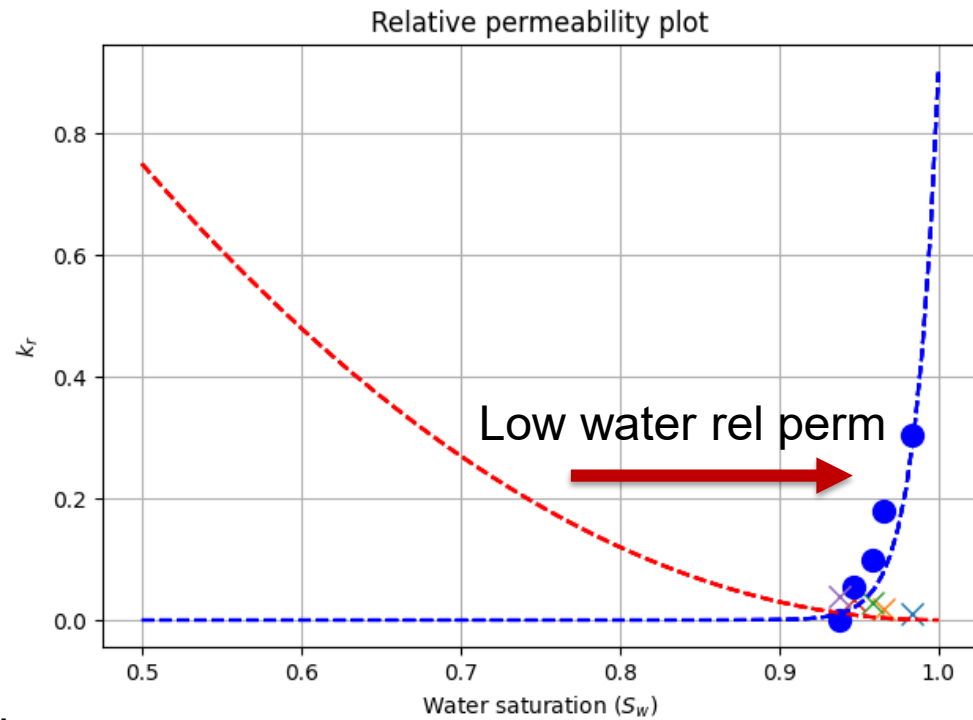


Less great trapping for vertical core

# Impact of heterogeneity on relative permeability



Low gas saturations



Low water rel perm



# Conclusions

1. A wide range of heterogeneities seen over a narrow interval
2. Relationship between porosity and permeability complicated by the presence of small-scale heterogeneities
3. Small-scale heterogeneities caused channeling of the CO<sub>2</sub> which led to:
  - › Low gas saturations caused by low pore volume utilization
  - › Steep reductions in water relative permeability
4. A large range of relative permeabilities seen over a narrow interval makes modelling difficult

Thank you for listening! Any questions?

Huge thanks to Adrian Sheppard for scanning the micro-CT core

# Overview of heterogeneities seen

