# Addressing the Challenges: Current Research into CCS

Neil Wildgust
Project Manager – Geological Storage
IEA Greenhouse Gas R&D Programme
CAGS Workshop, Changchun, July 2011


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power generation group
BG GROUP
bp
CEZ GROUP
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CIAB
VATTENFALL
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TOTAL
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Doosan Babcock
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Evaluating technology options to mitigate greenhouse gas emissions
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# IEA Greenhouse Gas R&D Programme

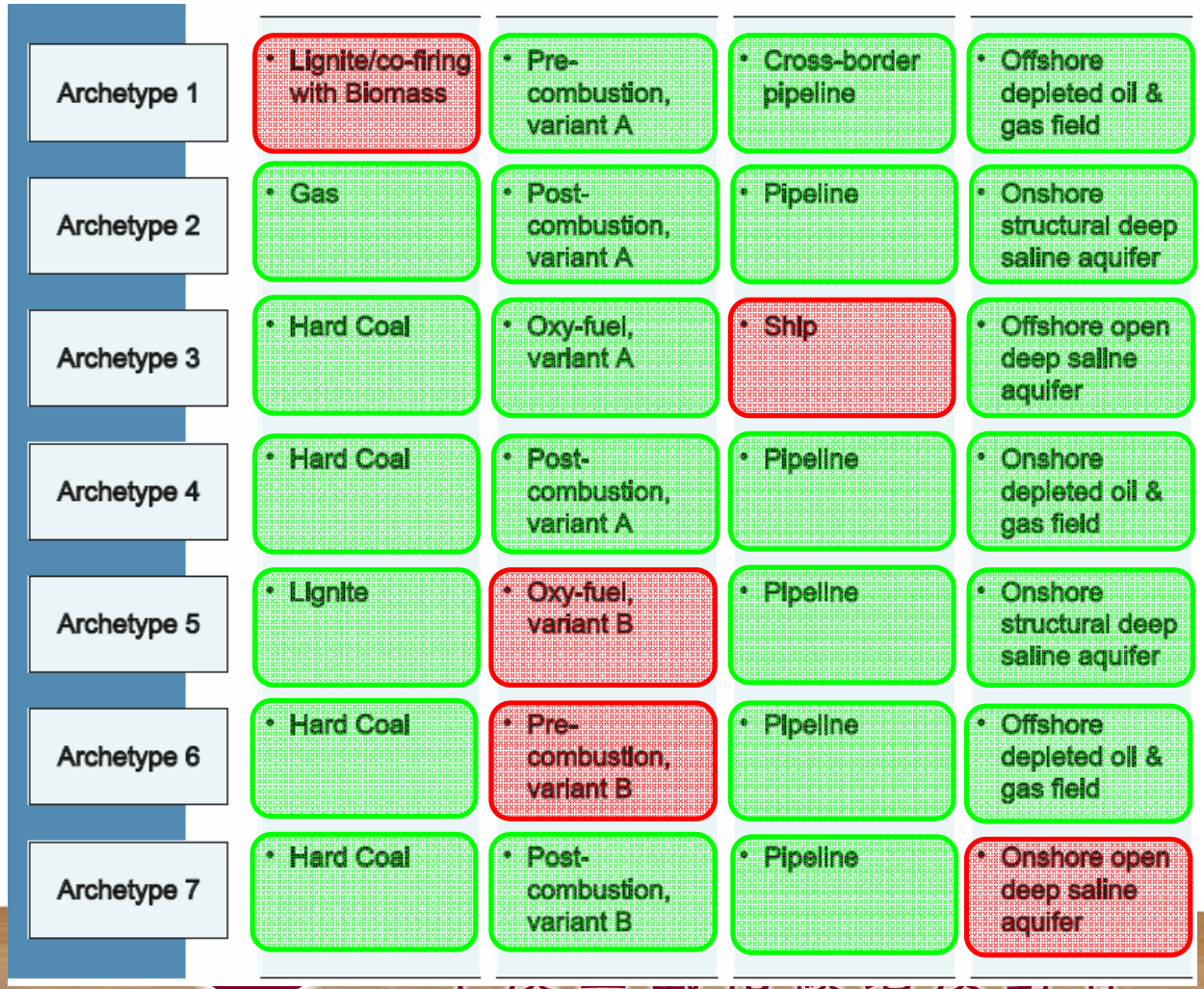
- IEAGHG aims at producing information that is:
  - Objective in evaluating the relative merits of Greenhouse Gas mitigation options
  - Information generated is policy relevant but NOT policy prescriptive
  - We aim to be a trustworthy source of technical information. All IEAGHG studies are:
    - Reviewed by external Expert Reviewers
    - Subject to review of policy implications by Members

# Projects identified (2009)

| | |
|---|---|
| Bellingham Co-Generation Facility | IFFCO $CO_2$ Recovery Plant - Aonla |
| Castor Project | Prosint Methanol Plant |
| Great Plains Synfuel Plant | Rangely $CO_2$ Project |
| IMC Global Soda Plant | Schwarze Pumpe |
| In Salah | SECARB - Cranfield II |
| K12-B | Shady Point Power Plant |
| Ketzin Project | Sleipner |
| MRCSP - Michigan basin | Snøhvit LNG Plant |
| Nagaoka | Sumitomo Chemicals Plant |
| Otway Basin Project | SRCSP – Aneth EOR-Paradox Basin |
| Pembina Cardium Project | SRCSP – San Juan Basin |
| Petronas Fertiliser Plant | Warrior Run Power Plant |
| IFFCO $CO_2$ Recovery Plant - Phulpur | Weyburn-Midale |
| Chemical CO. "A" $CO_2$ Recovery Plant | Zama EOR Project |

- Capture over 100 $ktCO_2$
- Capture over 10 $ktCO_2$ from Flue Gas
- Injection over 10 $ktCO_2$ for Storage
- Monitored EOR over 10 $ktCO_2$
- Coalbed Storage over 10 $ktCO_2$

# Extent of coverage vs ZEP project matrix

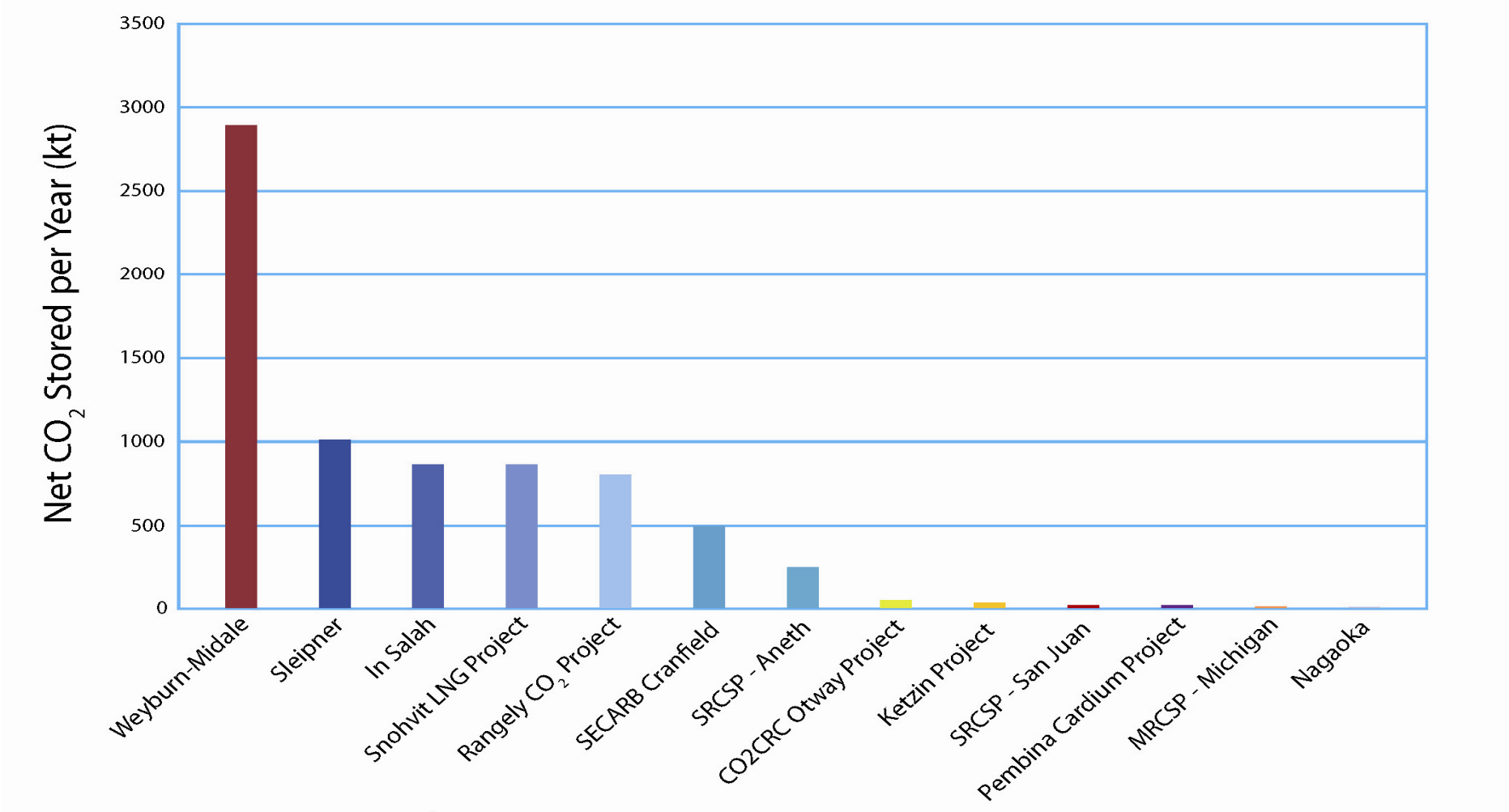



Demonstrated in operational large projects

Not demonstrated in operational large projects

Project matrix courtesy of EU Technology Platform for Zero Emission Fossil Fuel Power Plants - ZEP (2008)

# Storage rates

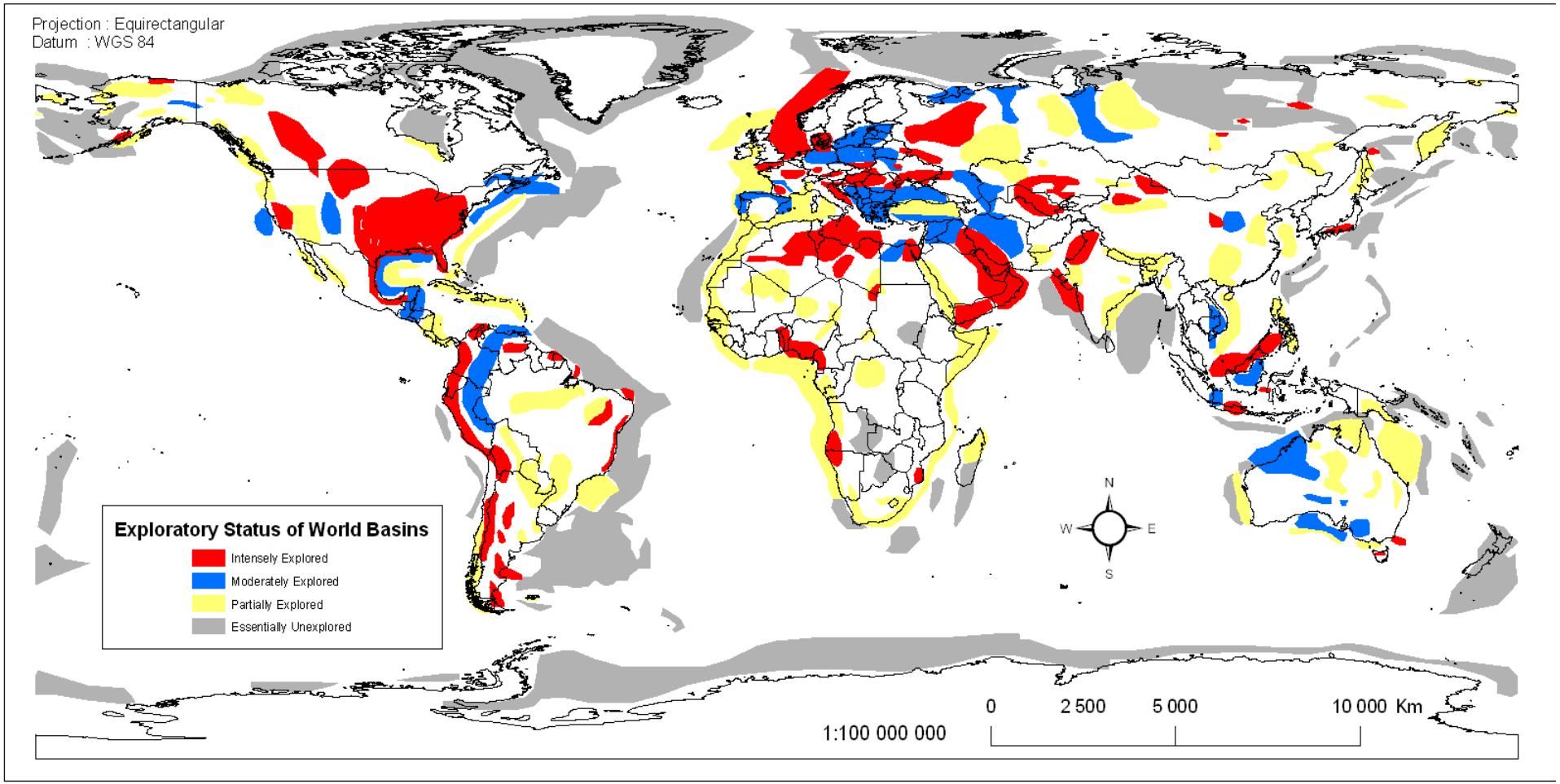


# Recent IEAGHG Storage Studies

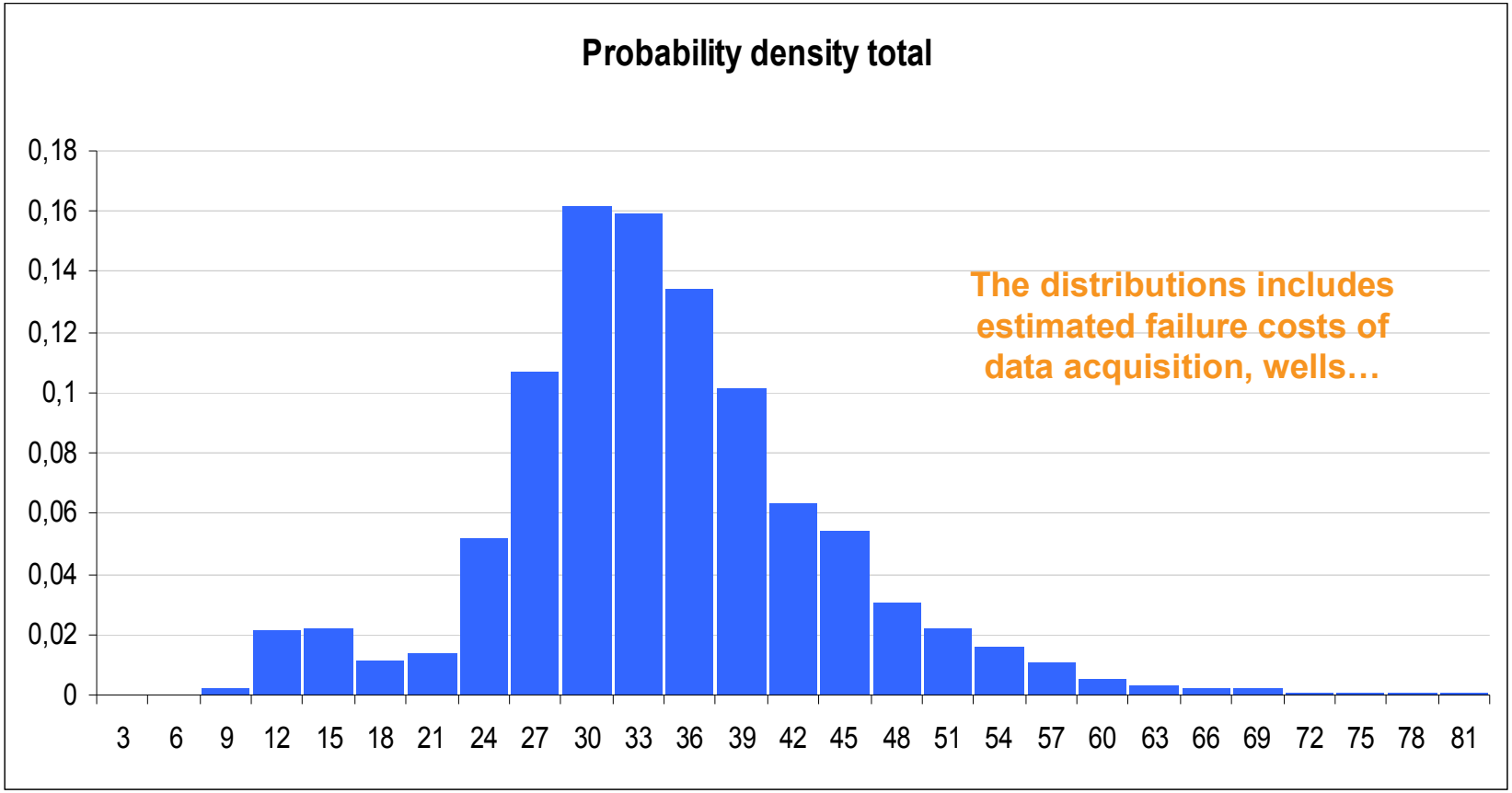
- GCCSI studies (Impurities, Gap Analysis)
- Storage Capacity Coefficients (EERC)
- Injectivity (CO2CRC)
- DSF brine and pressurisation (Permedia)
- Storage Costs (ZEP Phase 1)
- Caprock Systems (CO2CRC)
- Monitoring Other Substances (CO2GeoNet)
- Groundwater Impacts (CO2GeoNet)



# Basin Exploration Level



# Cost Distribution for Onshore DSF



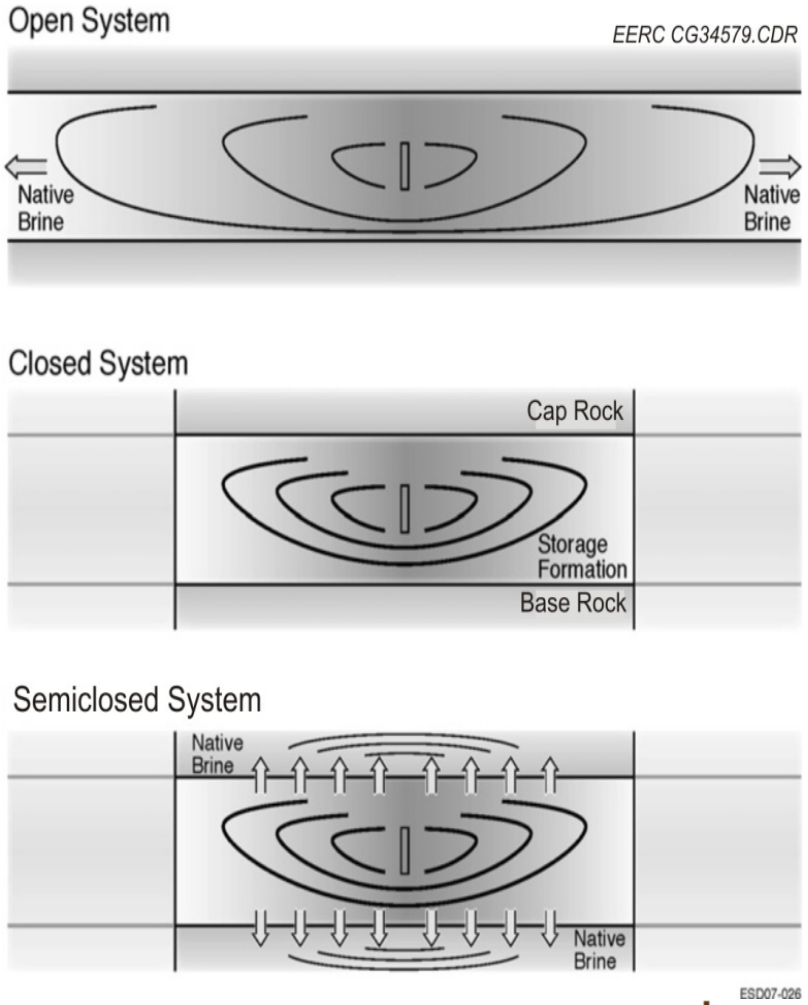
# Key Preliminary Conclusions – Gap Analysis Study

- Subject to expert review comments
- G8 objective (20 by 2020) achievable
- IEA objective (100 by 2020) impossible
- IEA objective achievable by 2028
- 100 bankable storage projects target requires 900MM to 4300MM Euros global investment by 2025

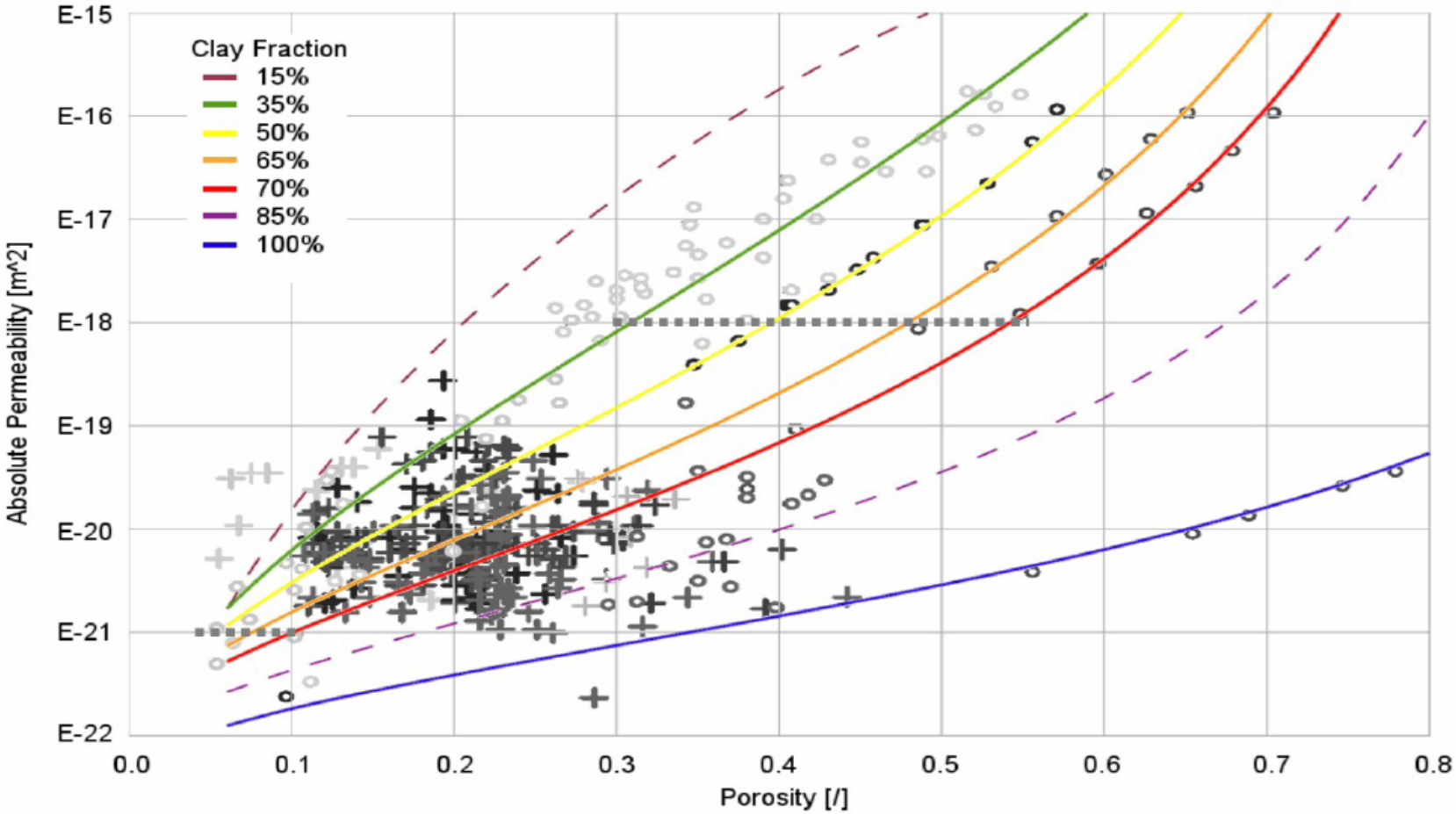


# Pressurisation Study - Permedia

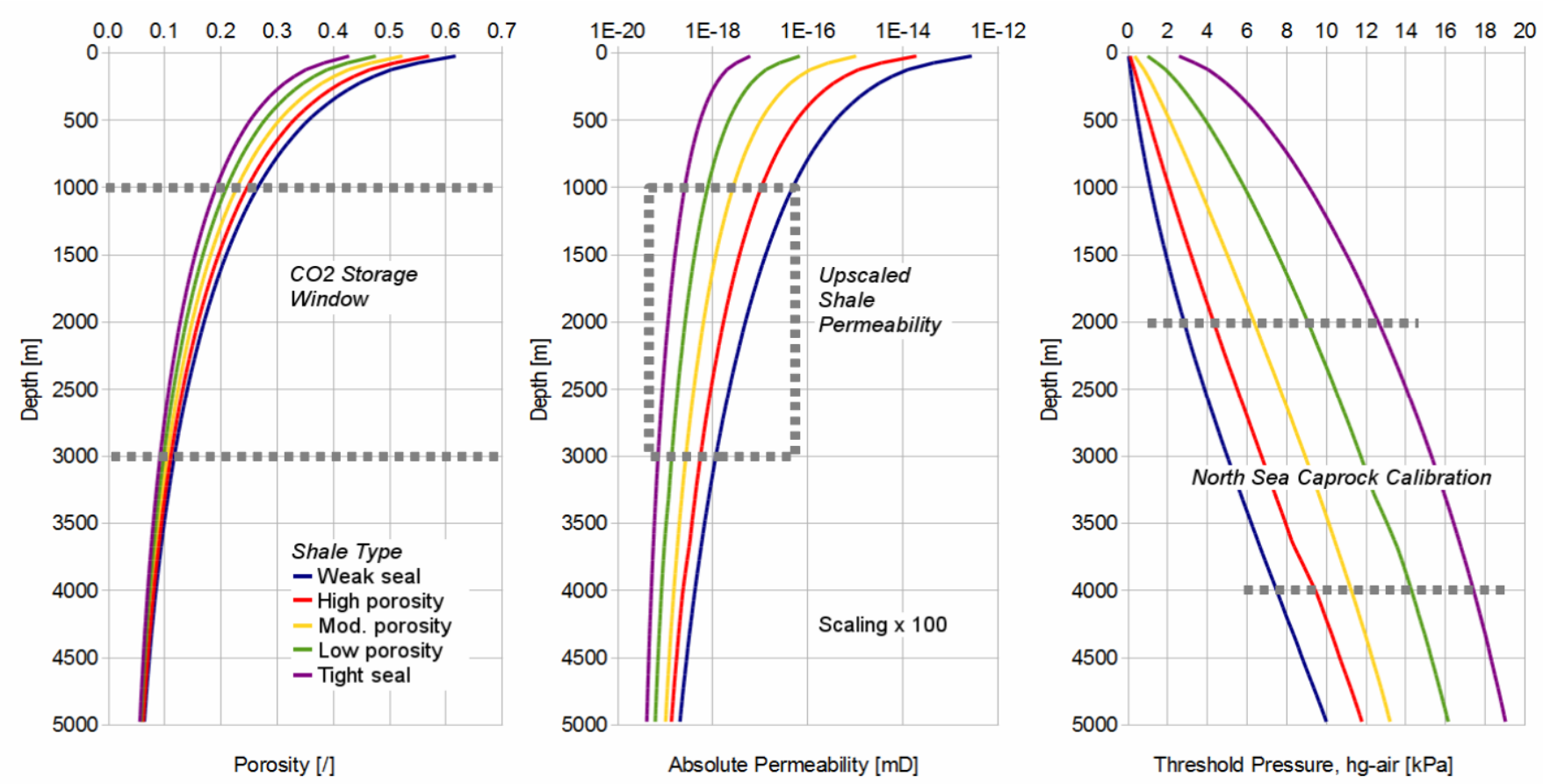
- Open systems: regional lateral brine flux, transient pressurisation
- Closed systems: brine flux within storage compartment, rapid loss of injectivity
- Semi-closed systems: more realistic?



# Shale Porosity-Permeability Transform
## (Young and Aplin 2009)



# Empirical Relationships affecting Regional Shale Permeability



# Permedia Conclusions

- Characterisation of regional shale properties is problematic (scale effects)
- Brine displacement may negate the adverse effects of pressurisation
- Shale caprocks with microdarcy permeability will allow brine migration
- Heterogeneity may affect use of abstraction wells for pressure relief ($CO_2$ breakthrough)
- Closed system assumption only valid for small pressure compartments



# Groundwater Impacts Study

- Study commissioned by IEAGHG and carried out by $CO_2$GeoNet
- Led by BRGM








China Australia Geological Storage of $CO_2$

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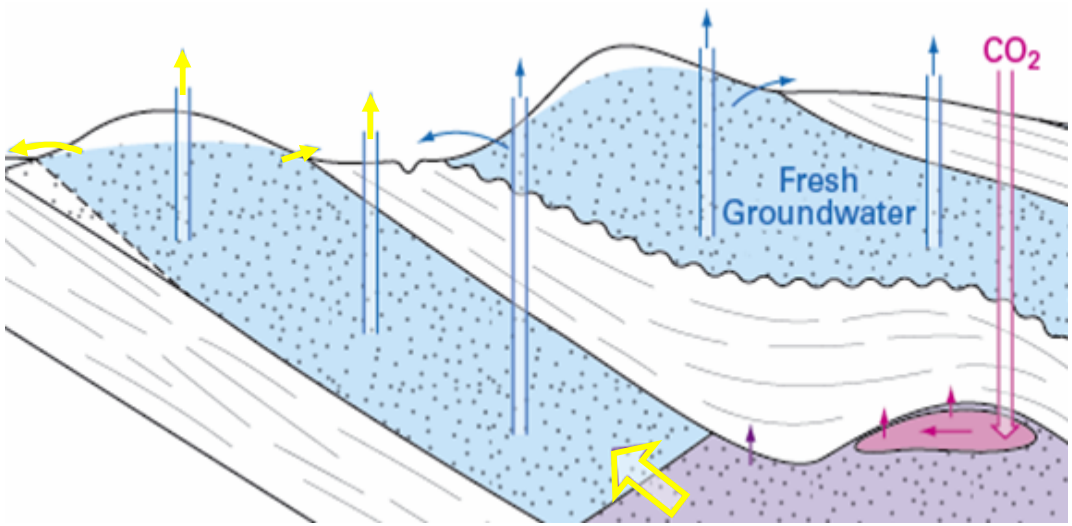
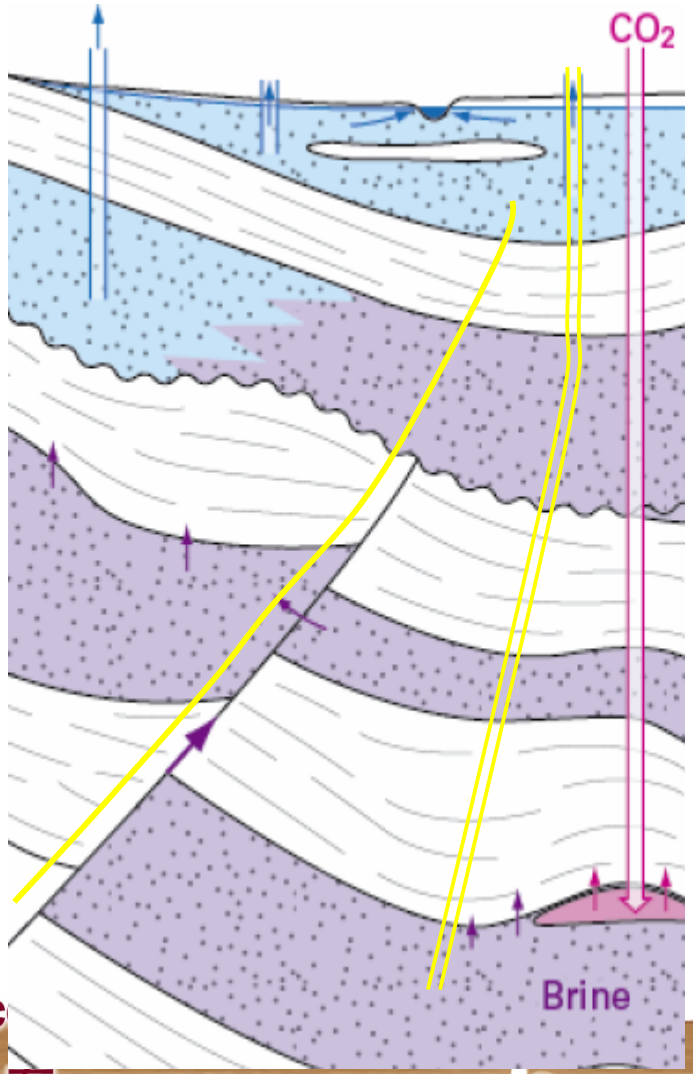
# Pressure effects

displacement of brine in ‘open’ aquifers cannot be avoided

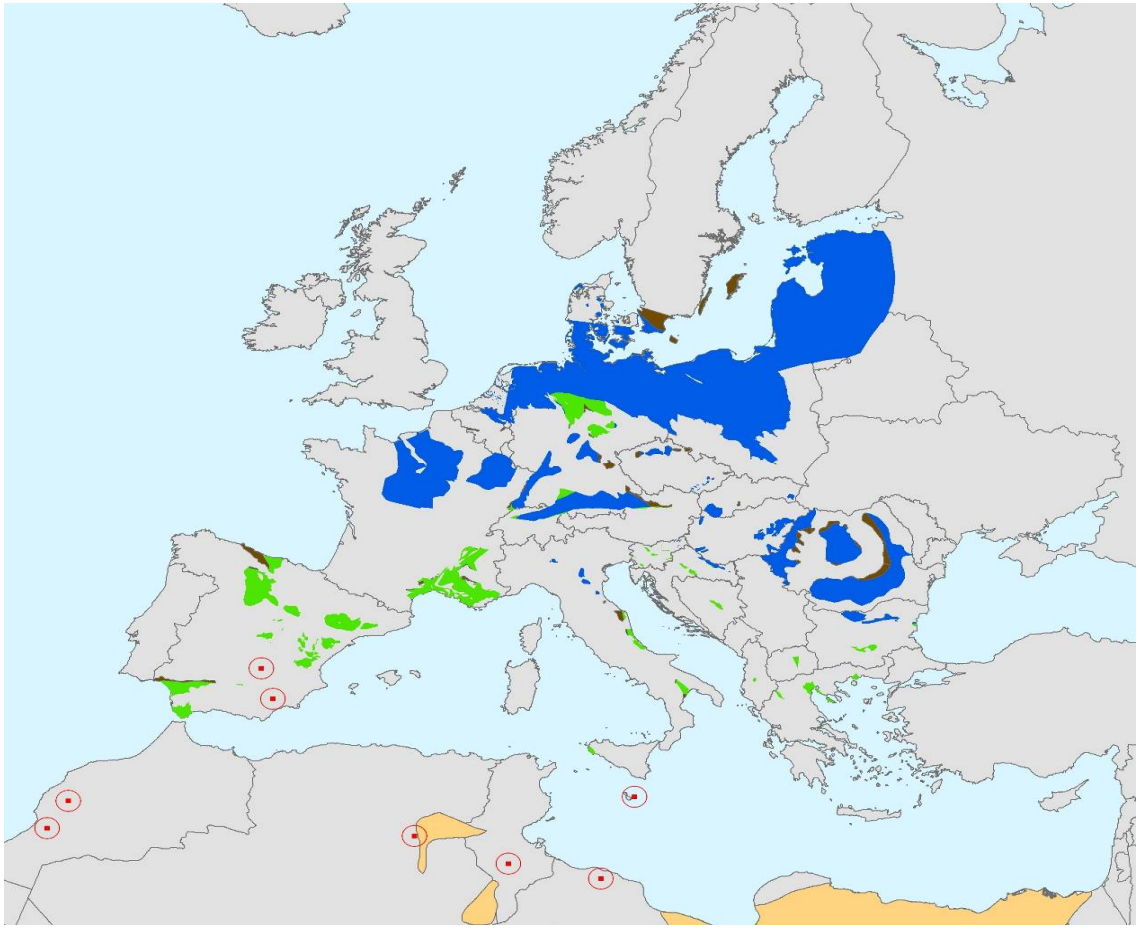


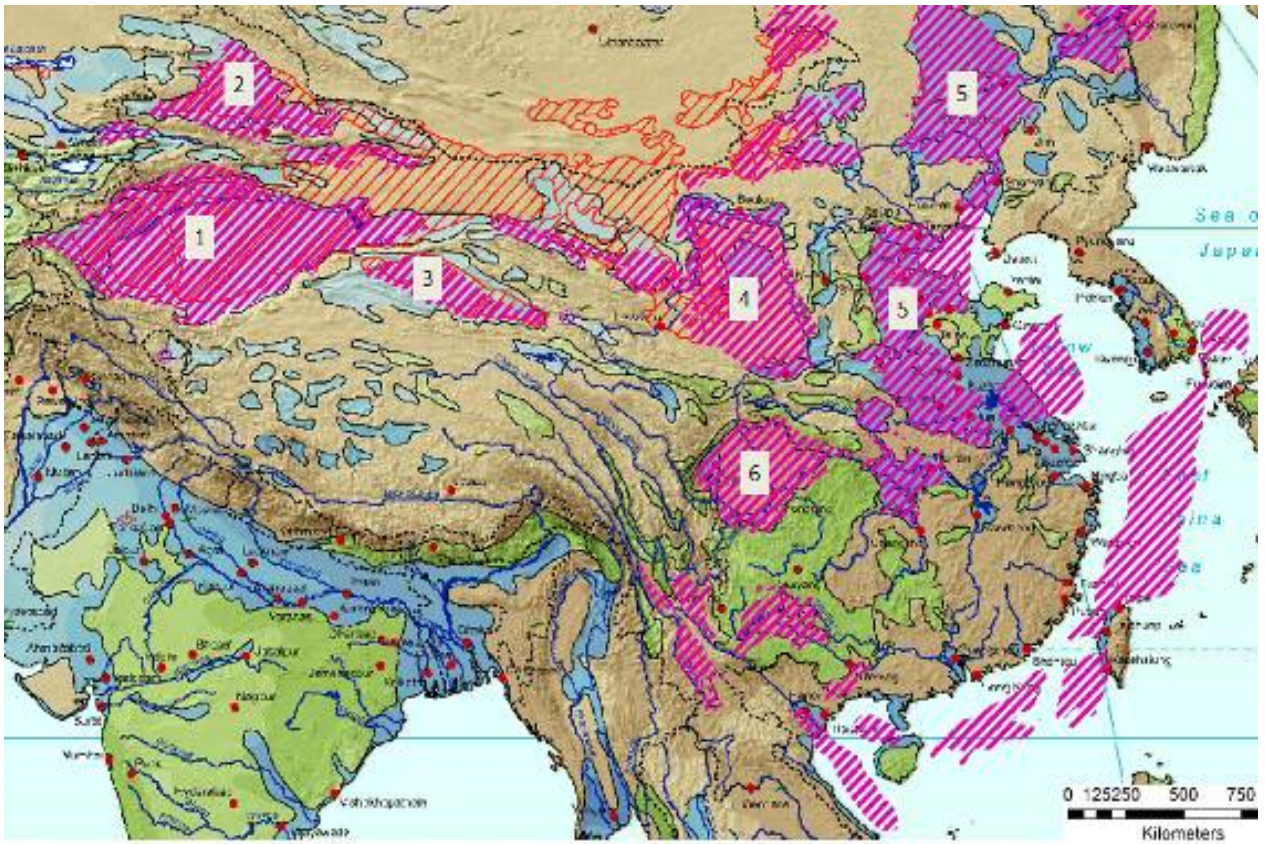

faults, abandoned wells

- characterization and monitoring of pathways

# Overlap of storage and groundwater resources in Europe



# Overlap of Groundwater and Storage Resources - China



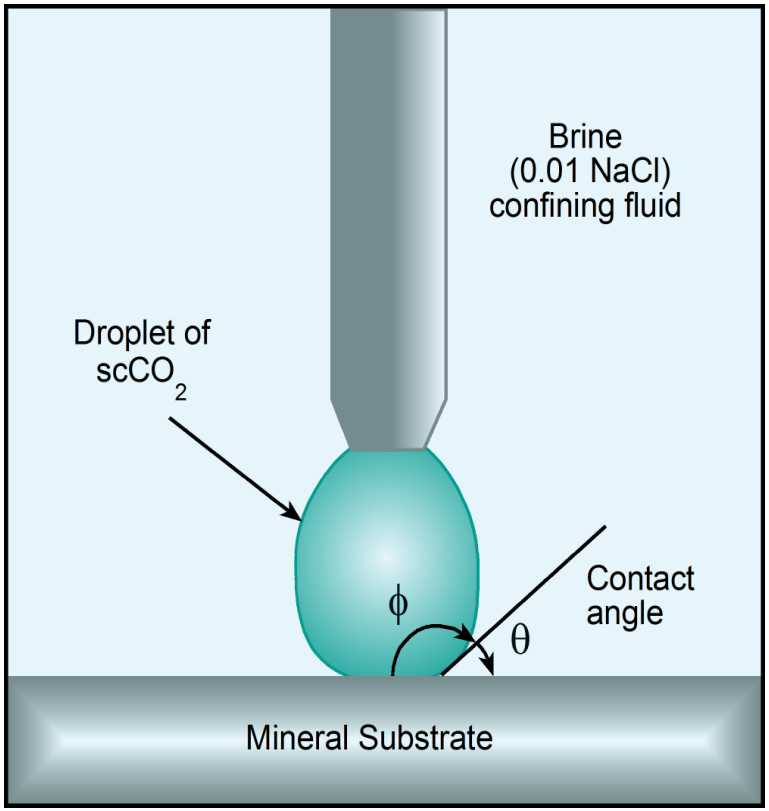
# Caprocks Study - Seal Potential

- Overall seal potential is a function of capacity, geometry and integrity of a caprock
- Capacity refers to maximum $CO_2$ column height that can be retained
- Geometry refers to the thickness and lateral extent of the caprock
- Integrity refers to geomechanical properties
- Report presents a qualitative assessment methodology for basin-level screening



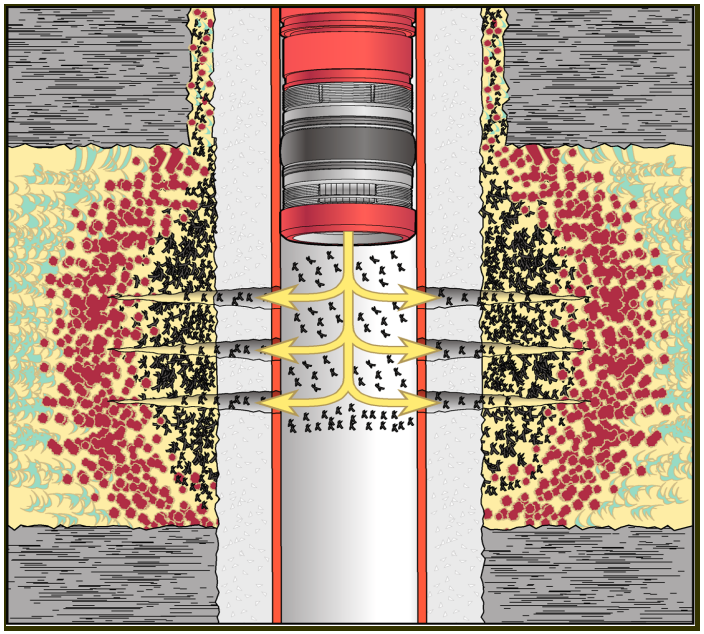
# Seal Capacity

- Controlling factors:
  - Pore throat size
  - Interfacial tension (IFT)
  - Wettability
- Effects of wettability assumptions on capacity
- Wettability/IFT of water-$scCO_2$ systems is a knowledge gap



# IEAGHG Storage Networks

## Wellbore Integrity Network



## Modelling Network

# Forthcoming IEAGHG Storage Studies

- Brine abstraction (EERC, US DOE co-funding)
- Implications for CCS of Shale Gas Extraction
- Resource Interactions for $CO_2$ Storage
- Induced Seismicity
- Phase 2 of Storage Costs (outside Europe)
- www.ieaghg.org