IEAGHG activities and networks in CCS and highlights of recent studies

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Mustang Consortium Meeting 3

Montpellier, June 2010


ALSTOM
B&W
power generation group
VATTENFALL
TOTAL
Statoil
BG GROUP
bp
CEZ GROUP
Chevron
Schlumberger
RWE
The energy to lead
CIAB
REPSOL YPF
ConocoPhillips
JGC
eni
e·on
GLOBAL CCS INSTITUTE
ExxonMobil
EPRI

IEAGHG Research Networks

- Facilitate discussions between international researchers and operators on key CCS topics
- Meet annually in various locations worldwide
- Participation open to all with professional interest in CCS
- Minimal registration fee for meetings

IEAGHG Modelling Network

- First meeting in Orleans, Feb 2009
- Second meeting in Utah, Feb 2010
- 2011: offer to host by Shell and University of W Australia
- Network details at www.ieaghg.org

Risk Assessment Network

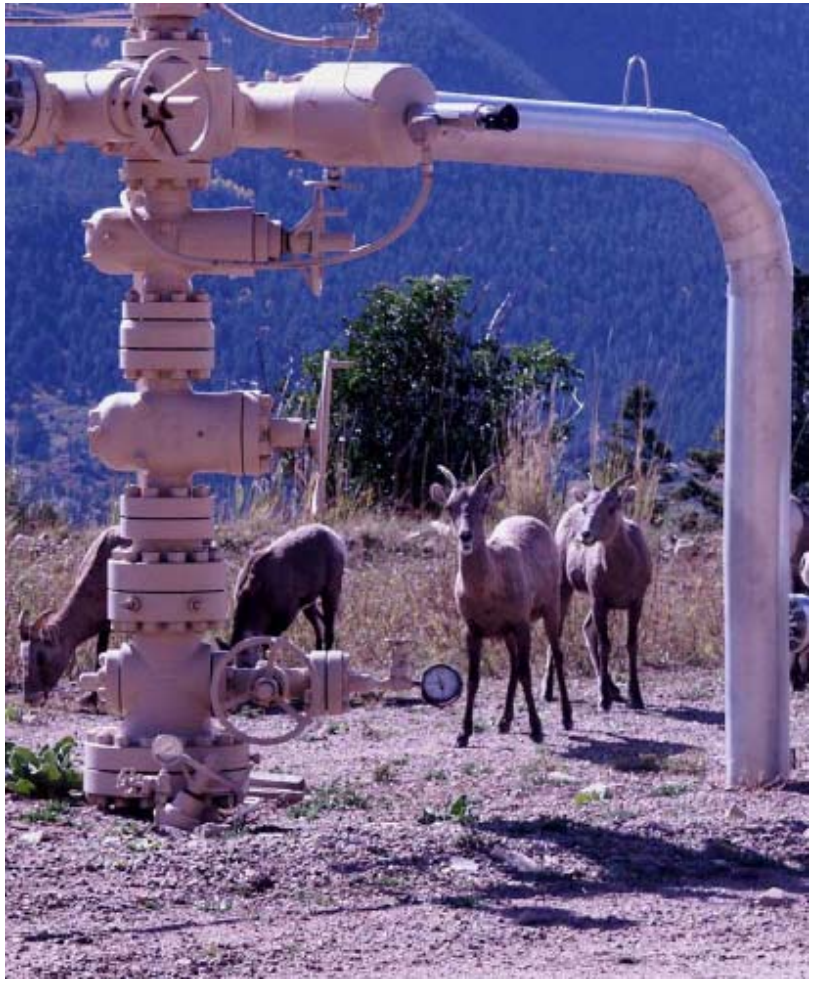
- First meeting in Utrecht, Aug 2005
- 2010 meeting in Colorado, May 2010
- 2011: offer to host by BRGM, Orleans
- Network details at www.ieaghg.org

Monitoring Network

- First meeting in California, Nov 2004
- 2010 meeting in Natchez, Louisiana
- 2011: offer to host by CO2Store, Ketzin
- Network details at www.ieaghg.org

Wellbore Integrity Network

- First meeting in Houston, Apr 2005
- 2010 meeting in The Hague, Apr 2010
- 2011: offer to host by Shell and University of W Australia
- Network details at www.ieaghg.org



Social Research Network

- First meeting in Paris, Dec 2009
- 2010 meeting in Japan, Nov 2010
- Network details at www.ieaghg.org

IEAGHG Study Programme

- Study ideas/proposals welcome from any source
- Typical duration 6 months, cost £50k to £100k
- Proposals put through ExCo voting process every 6 months
- Typically 10 to 20 studies published per year
- Majority of studies contracted out

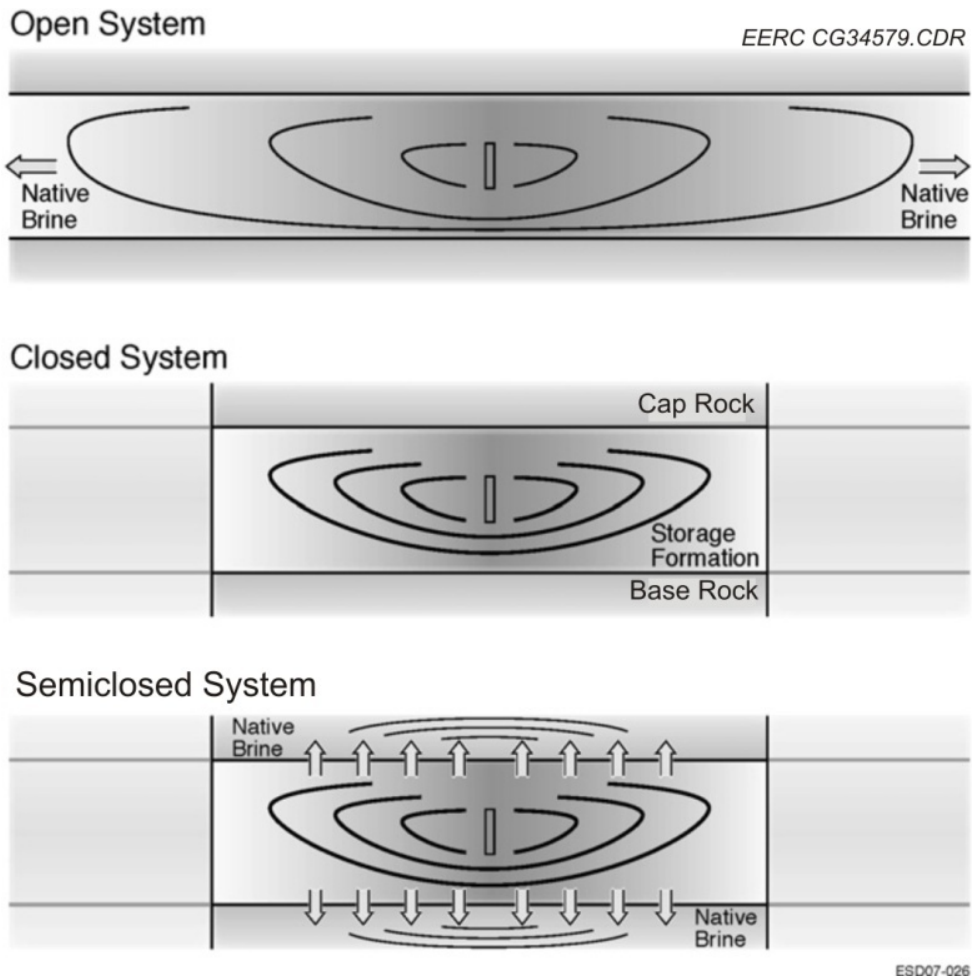
Recent CO_2 Storage Studies

- Storage Capacity Coefficients
- Global Storage Potential for CO2-EOR
- Injection Strategies
- Brine Displacement and Pressurisation
- Potential Impacts on Groundwater Resources
- Effects of Impurities
- Storage Resource Gap Analysis
- Caprock Systems for Storage

Storage Capacity Coefficients Study

- CSLF and US DOE storage resource estimation methodologies require development of coefficients
- Study undertaken by Energy and Environment Research Centre, University of North Dakota
- Co-sponsored by US DOE
- Main aims of the study:
  - Review storage resource estimation methodologies and associated resource classification schemes;
  - Compile database of key parameters from injection projects and associated modelling studies;
  - Develop a series of storage coefficients that can be applied to regional resource surveys;
  - Consider hydrocarbon fields and saline formations

Deep Saline Formations



Methodology

- Paucity of ‘real-world’ projects and data
- Approach employed: modelling from database of likely DSF characteristics developed from HC field databases and literature search
- Provided statistical datasets for modelling
- Uniform injection and evaluation scheme developed for modelling runs
- Coefficients for ***Effective Capacity (CSLF) or Resource (US DOE)*** derived at site scale and extrapolated to formation scale

Modelling

- Initial homogeneous models to test parameter sensitivity
- Approximately 200 simulations run with statistically-derived heterogeneous models
- Coefficients derived for 3 rock-types
- Structural setting found to exert biggest influence on storage efficiency at site scale
- Site scale modelling results extrapolated to formations scale, assuming open system

Formation Scale Coefficients

Lithology	Storage Coefficients (%) by probability percentile		
	P10	P50	P90
Clastics	1.9	2.7	6.0
Dolomite	2.6	3.3	5.5
Limestone	1.4	2.0	3.3
All	1.7	2.6	5.1

Injection Strategies Study

- Study completed in 2010 by CO2CRC, project team led by Karsten Michael
- Assessed parameters that can influence injection,
- Consider methods of design of injection strategies,
  - Case studies to demonstrate different strategies,
- Assess technical aspects of well design,
- Cost estimation tool:
  - Comparative rather than predictive.

Moving up in scale

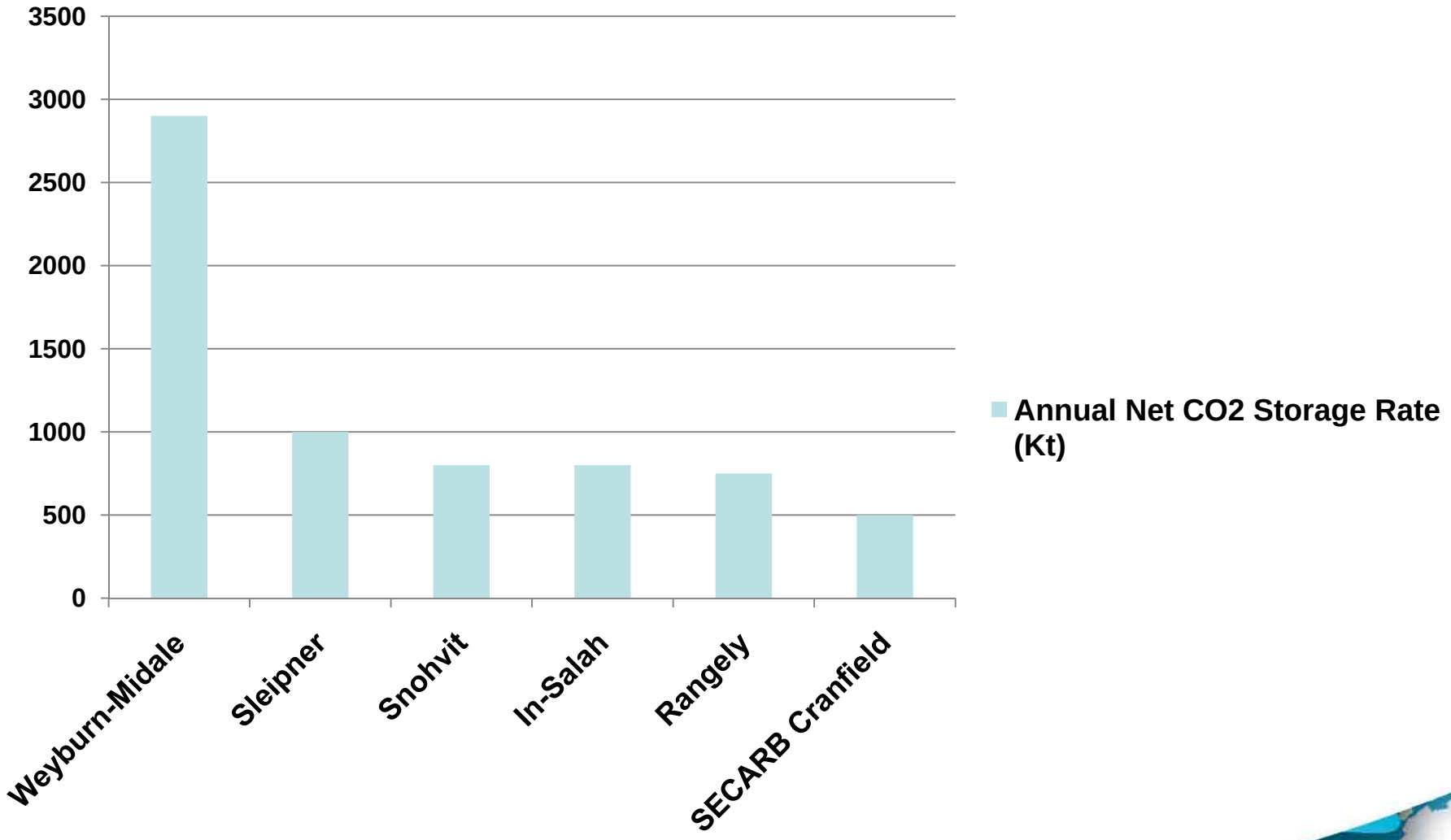
- Key issue for considering injections strategies;
- Injection rates on the order of 10 $MtCO_2$/year for many sites;
- CCS infrastructure will need to be of the same scale as that of the current petroleum industry;
- Storage process will need to be optimised by multi-well schemes and enhancement of dissolution;
- Management of reservoir pressures (water production) to avoid fracturing, seismic events and impact on resources (groundwater, petroleum).

Active projects, early 2009

Bellingham Cogeneration Facility	IFFCO CO2 Recovery Plant – Aonla
CASTOR Project	Prosint Methanol Plant
Great Plains Synfuel Plant	Rangely CO2 Project
IMC Global Soda Plant	Schwarze Pumpe
In Salah	SECARB - Cranfield II
K12-B	Shady Point Power Plant
Ketzin Project	Sleipner
MRCSP - Michigan Basin	Snohvit LNG Project
Nagaoka	SRCSP - Aneth EOR-Paradox Basin
Otway Basin Project	SRCSP - San Juan Basin
Pembina Cardium Project	Sumitomo Chemicals Plant
Petronas Fertilizer Plant	Warrior Run Power Plant
IFFCO CO2 Recovery Plant - Phul	Weyburn
Chemical Co. "A" CO2 Recovery Plant	Zama EOR Project

- Capture over 100ktCO_2
- Injection over 10ktCO_2 for storage
- Monitored EOR over 10ktCO_2
- Capture over 10ktCO_2 from flue gas
- Coal bed storage over 10ktCO_2

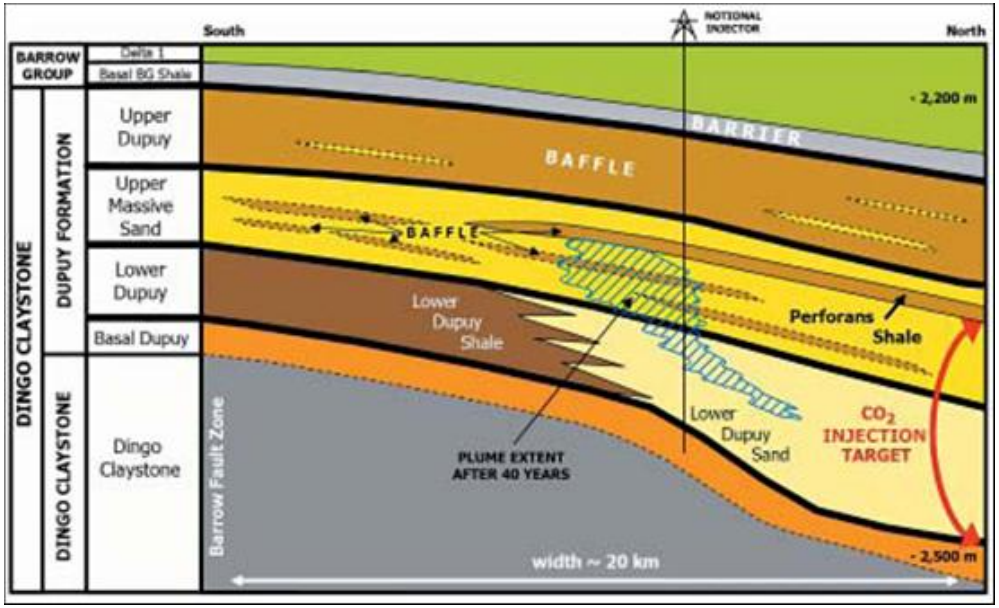
Net CO_2 Storage per Year

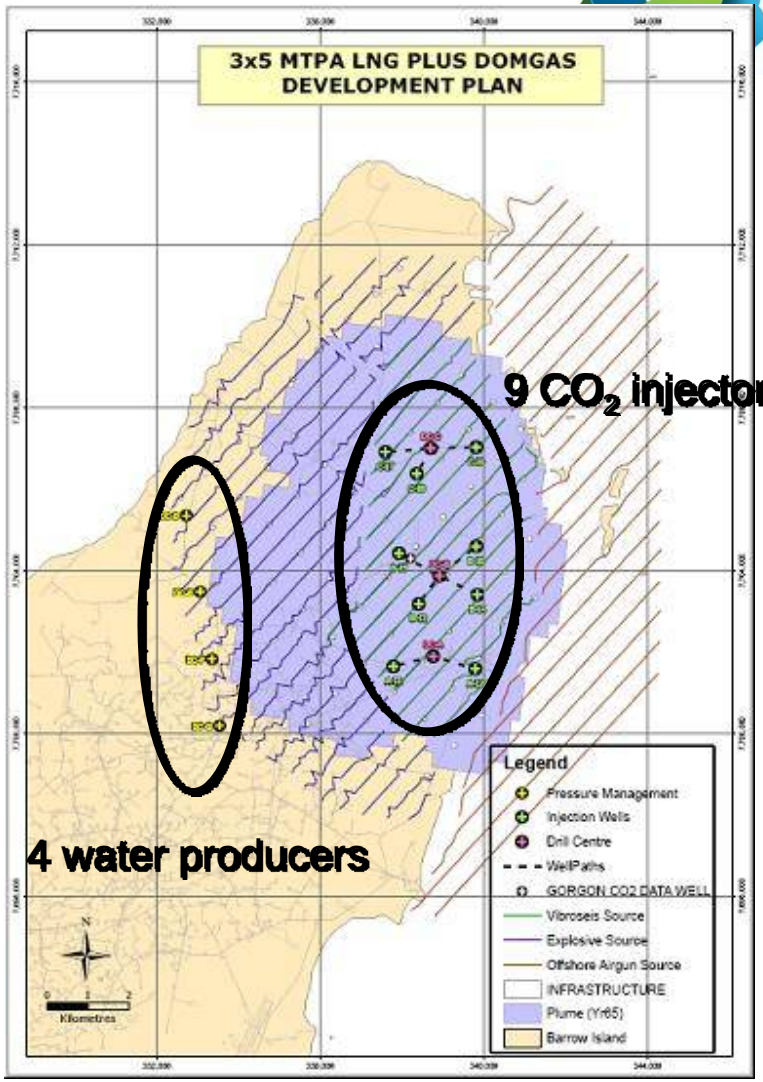


Injection Strategy Concepts

- Injectivity: the ability of a geological formation to accept fluids by injection through a well or series of wells.
- Primary influence is bottom-hole pressure, influenced by injection rate, permeability, formation thickness and depth, CO_2/brine viscosity, compressibility....
- Heterogeneity
- Pressure maintenance
- Co-injection
- Dissolution in formation brine
- Injection below oil-water contact

Pressure Maintenance - Gorgon Proposal





Pressurisation and Brine Displacement Study

- Overall study aim will be to investigate potential problems of pressurisation and brine displacement in multiple injection scenarios
- Some specific assessment objectives:
  - Evolution of pressure fields with time
  - Effects on caprock integrity, faults
  - Magnitude of brine displacement
  - Storage capacities, engineered solutions
- Study undertaken by Permedia Research

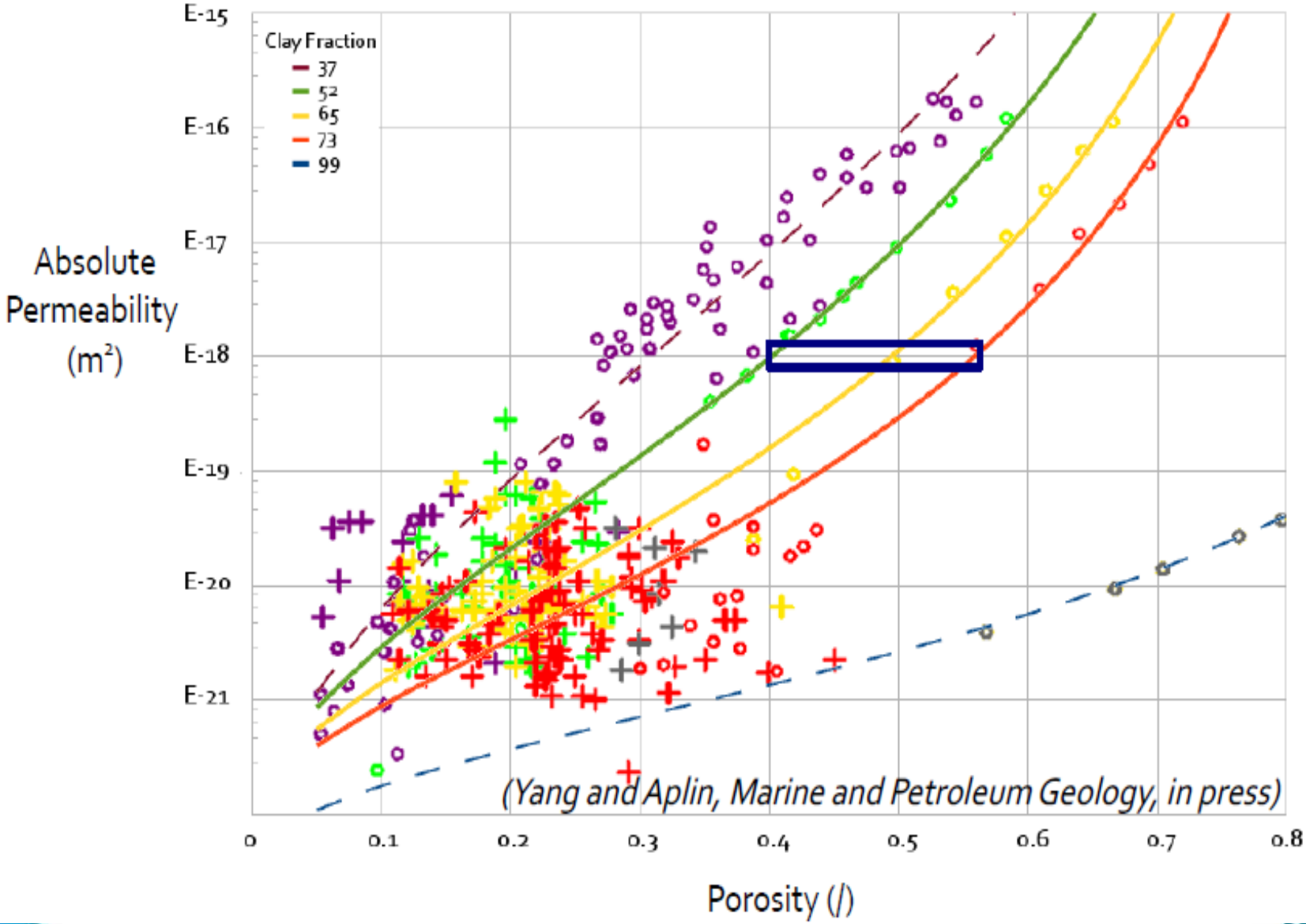
Shale Permeability

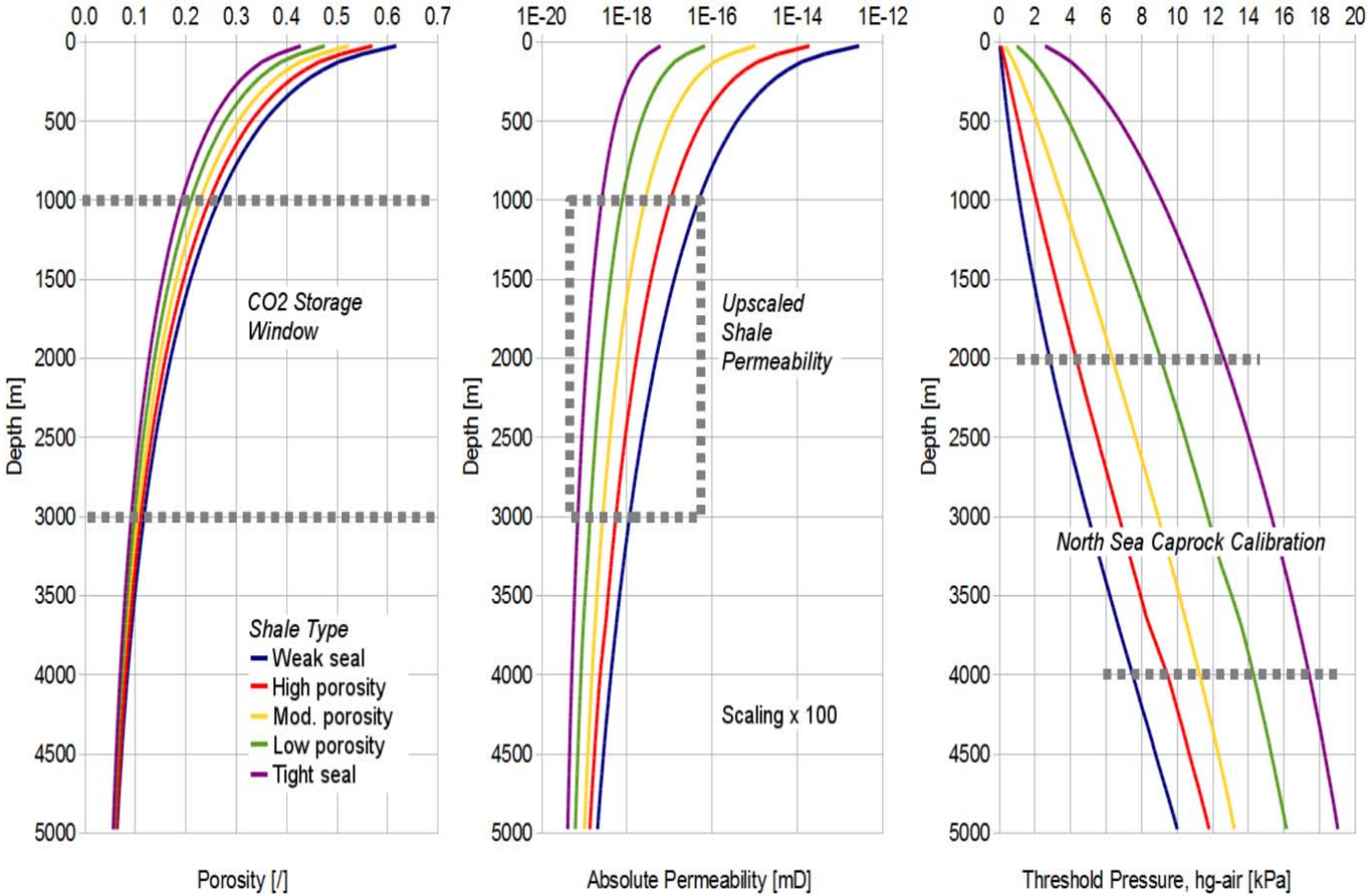
CO2 Storage	*Model*	*Depth (m)*	*Boundary k (m^2)*	*Response*
Thibeau & Mucha, 2009	Analytical	-	E-17	Dynamic capacity
Holloway *et al.*, 2009	Bunter Fmn	1,000-3,000	E-19	Dynamic capacity
Zhou et al., 2008	Analytical	-	E-17 to E-19	Dynamic capacity
Economides, 2009	Analytical*	-	<<E-22	Loss of injectivity
van der Meer, 2006	Analytical	-	<<E-22	Loss of injectivity

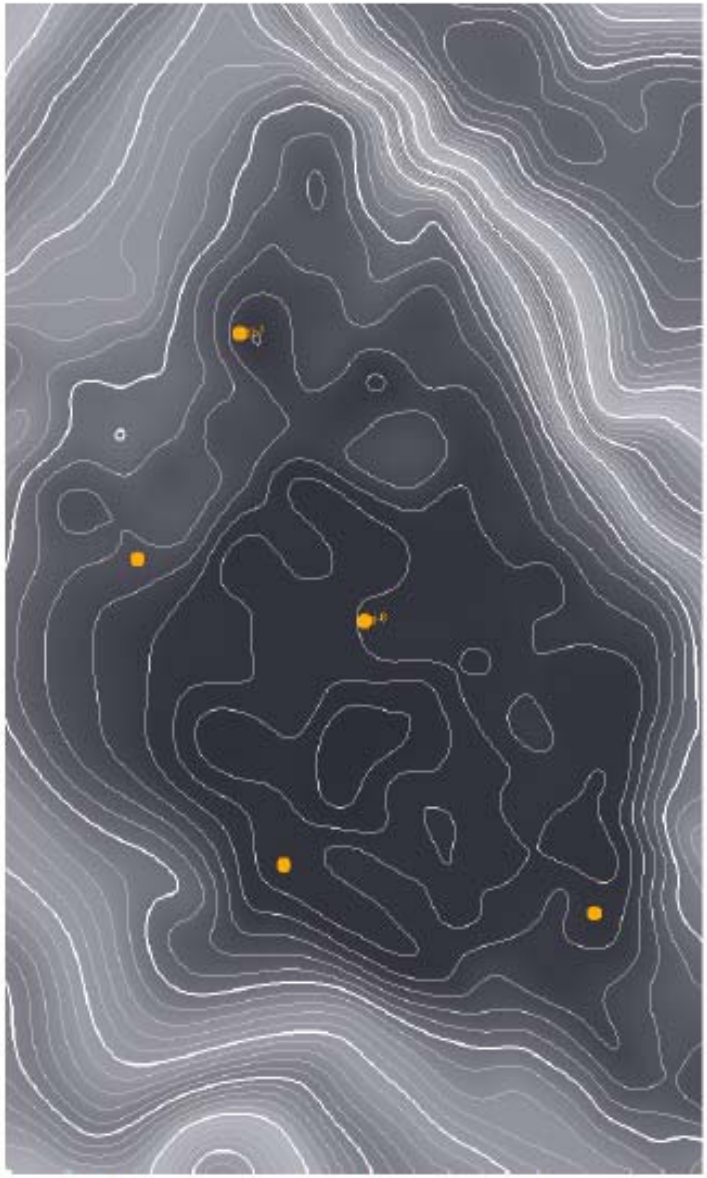
Overpressure	*Model*	*Caprock (m)*	*Caprock k (m^2)*	*Duration (Ma)*
Corbet & Bethke, 1992	W. Canada	500	E-20	3
He & Corrigan, 1995	Analytical	100-1,000	E-19 to E-21	1
Swarbrick *et al.*, 2000	Central North Sea	450	E-21	3

Threshold Pressure	*Observation*	*Depth (m)*	*Pth range (MPa)*	*Equivalent k (m^2)*
Nord' Bolas *et al., 2005*	North Sea (55)	2,000-4,000	2 to 18 (5 to 15)	*E-17 to E-19*
Bunney & Cawley, 2007	Forties Field	2000	15	*E-19*

Empirical porosity-permeability relationship




0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
Depth [m]
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000
CO2 Storage Window
Shale Type
Weak seal
High porosity
Mod. porosity
Low porosity
Tight seal
Porosity [/]
1E-20 1E-18 1E-16 1E-14 1E-12
Upscaled Shale Permeability
Scaling x 100
Absolute Permeability [mD]
0 2 4 6 8 10 12 14 16 18 20
North Sea Caprock Calibration
Threshold Pressure, hg-air [kPa]



IEAGHG Case Study, 17 x 27 km

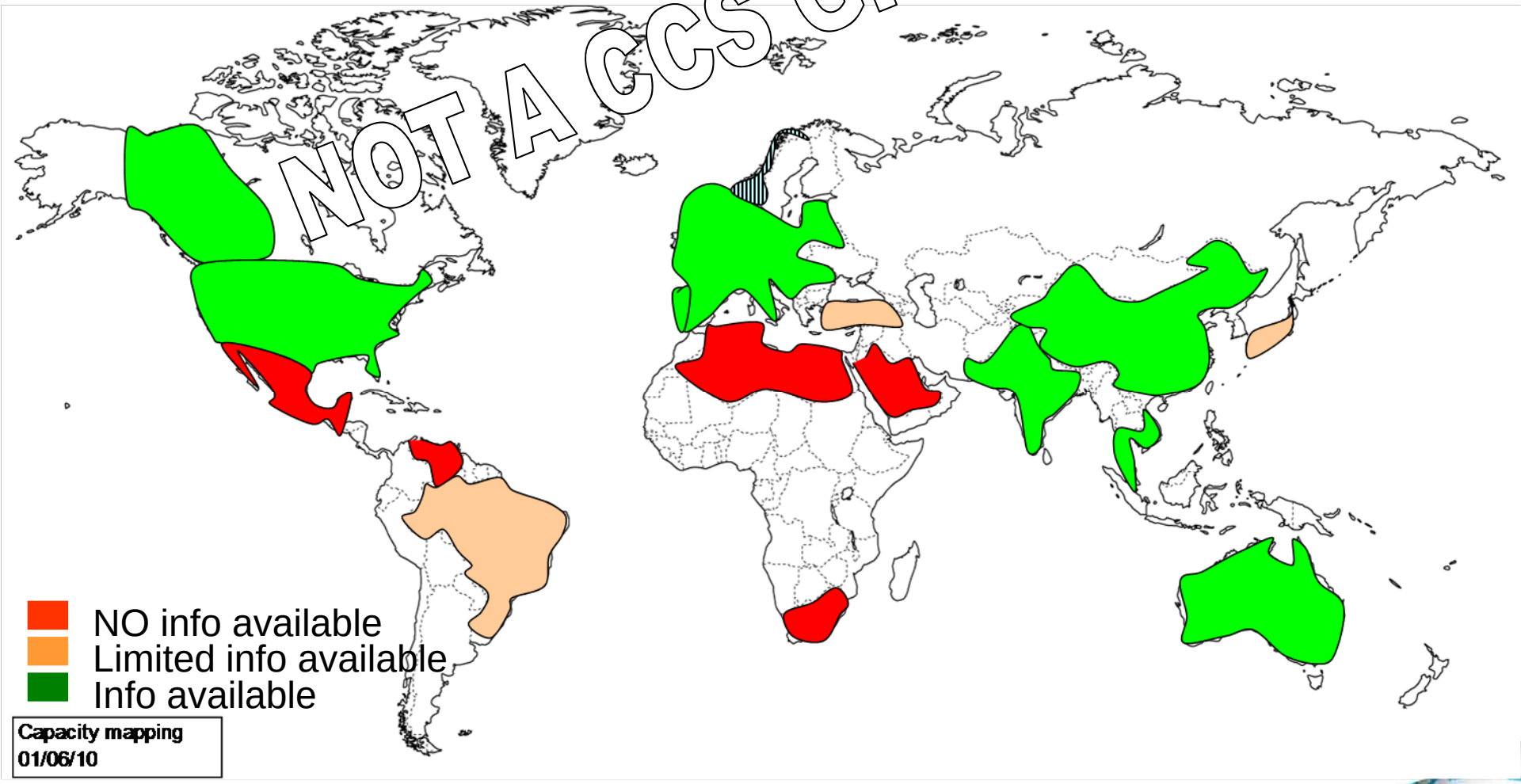
Conclusions

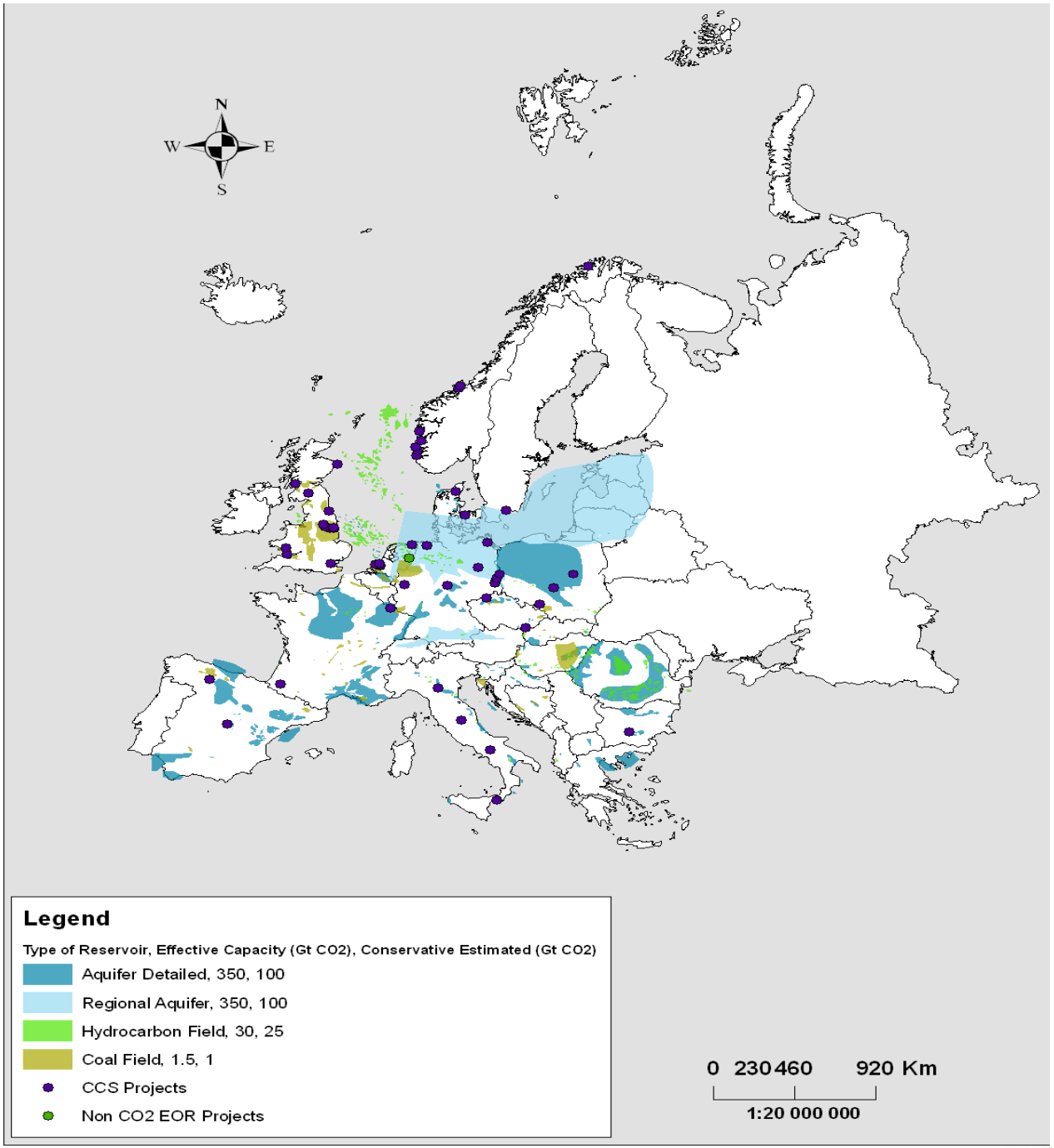
- Are closed boundaries a good approximation for storage sites?
  - E-21: yes
  - E-18: no
- Is the rock matrix porosity the principle flow medium in shales?
  - Probably not
- Are micro-to-mesoscale measurements valid constraints for macroscopic flow simulations?
  - Not for shales

Storage Resource Gap Analysis Study

- Contract awarded to Geogreen
- Aims of study:
  - Alert policymakers to the scale, cost and timing of the storage resource assessment tasks required to enable the initial deployment by 2020 of 20 commercial-scale CCS projects (G8) and the 100 projects (IEA Technology Roadmap)
  - Actions to launch in order to reach the IEA CCS target by 2050
  - Have sufficient storage sites identified and characterized to bankable status no later than 2015
  - Give insight of how resources can be effectively targeted, for each major world region, to ensure that wider implementation of CCS will be supported by an adequate availability of technically viable storage sites

Status of Information on storage capacity mapping




N
W
E
S
Legend
Type of Reservoir, Effective Capacity (Gt CO2), Conservative Estimated (Gt CO2)
Aquifer Detailed, 350, 100
Regional Aquifer, 350, 100
Hydrocarbon Field, 30, 25
Coal Field, 1.5, 1
CCS Projects
Non CO2 EOR Projects
0 230 460 920 Km
1:20 000 000

Concluding Remarks

- For storage in DSF, closed-system models are unlikely to be representative of most sites;
- Nevertheless, pressure build-up is most influential factor on injectivity and storage potential;
- Pressure management will therefore prove a vital element of injection strategies,
- Large scale demonstrations will enhance knowledge and understanding.

Thank you