The Current Status of Geological Storage of CO_2

John Gale

General Manager

IEA Greenhouse Gas R&D Programme

Seminar on

Carbon Capture and Storage (CCS)

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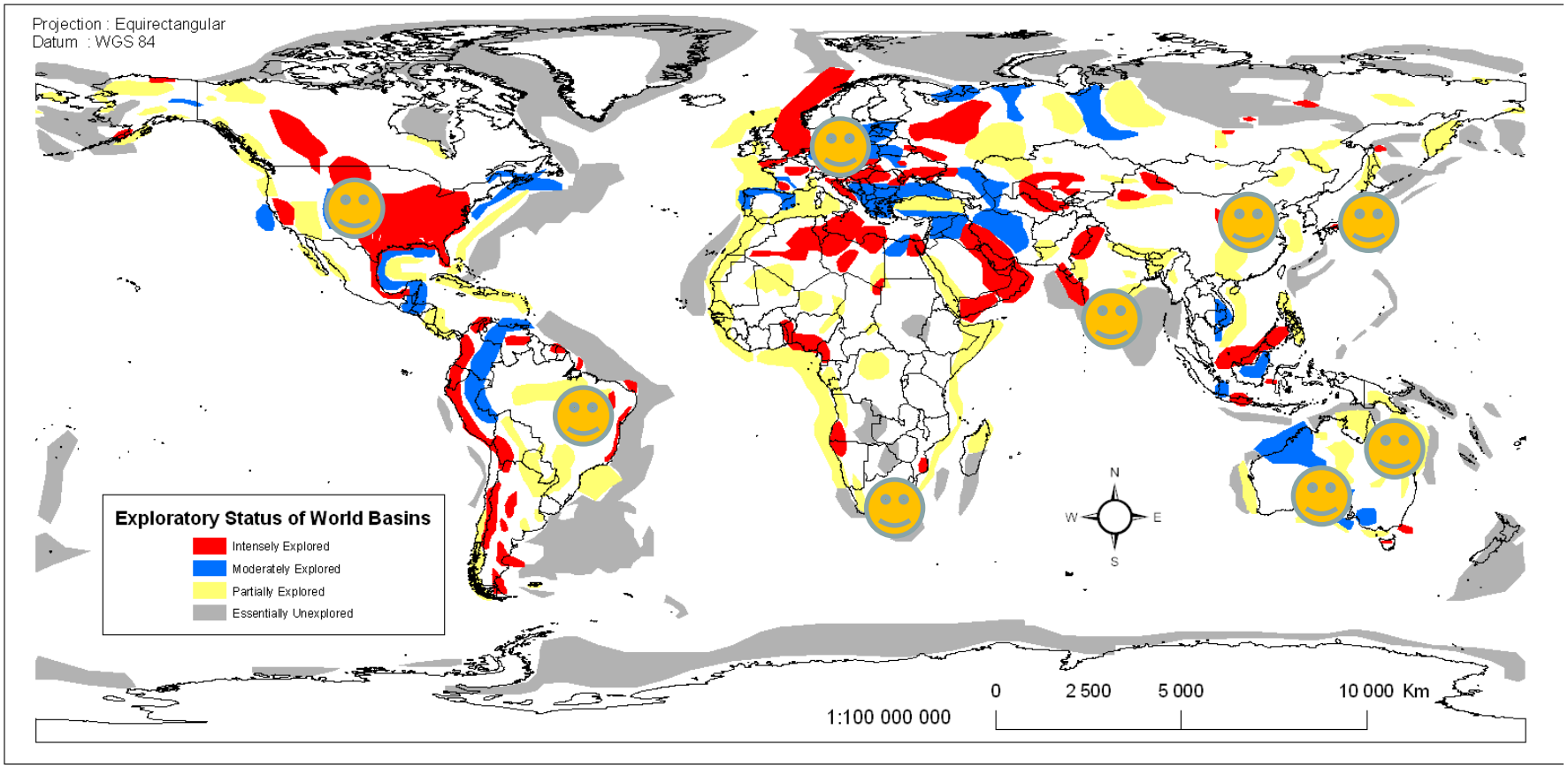
Introduction

- Cover Global Storage Capacity issues
- What is current state of knowledge on geological storage?
- Issues going forward

Knowledge Base

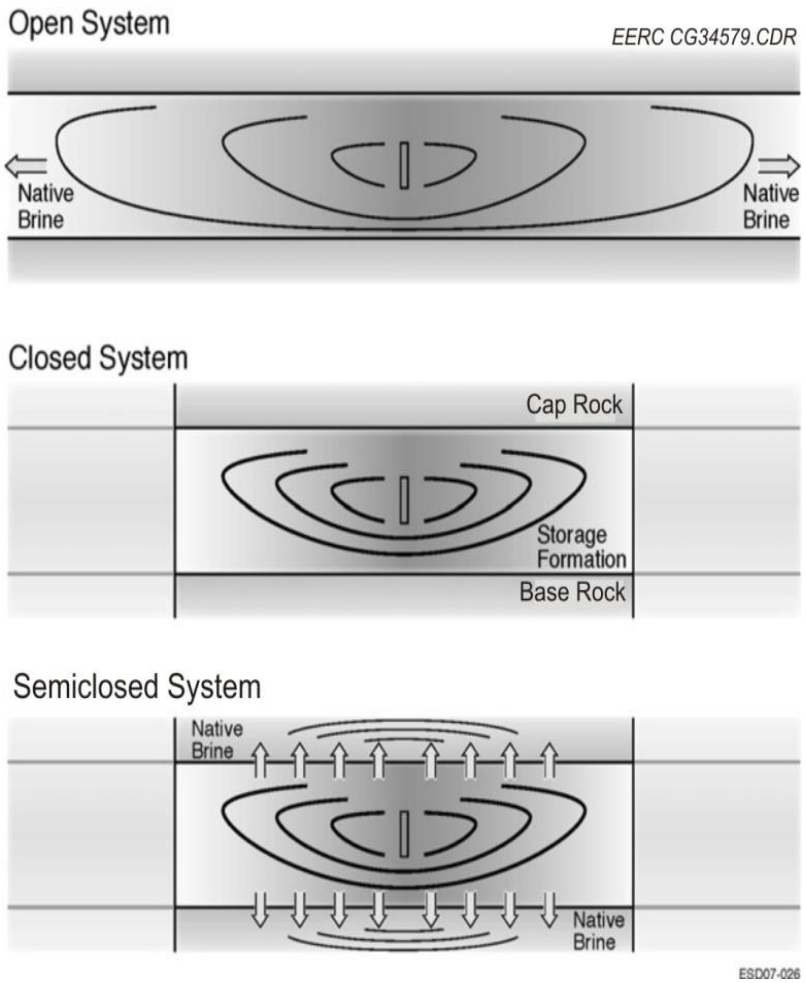


Capacity Estimates (Gt CO_2)

Storage Type	Global (IPCC 2005)	Global (IEAGHG)	USA	Europe
DSF	1,000 – 10,000	20,000	3,300 – 13,000	90 – 330
Depleted Gas	680 – 900	160	140	20 - 32
CO2-EOR		65		

Closed versus Open DSF Systems

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



Learning from Projects

- IEAGHG has assessed the existing body of knowledge on CCS
  - Large scale projects around the world that encompass parts of the CCS chain
  - Not fully integrated projects
  - Criteria: 10kT CO_2/year injection rate
  - Repeated on a 2 year cycle
- Provide an overview of that work supplemented in cases by other IEAGHG work

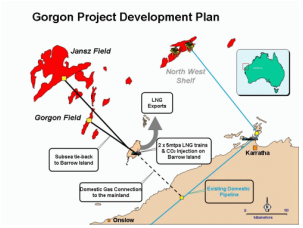
Commercial Application of CCS (to date)

Sleipner
1Mt/y CO_2

Weyburn
2.5 Mt/y CO_2

In-Salah
1.2 Mt/y CO_2

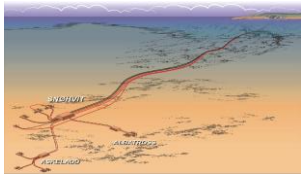
Snohvit
0.7Mt/y CO_2



Gorgon
3Mt/y CO_2

20 Integrated Demonstration Projects

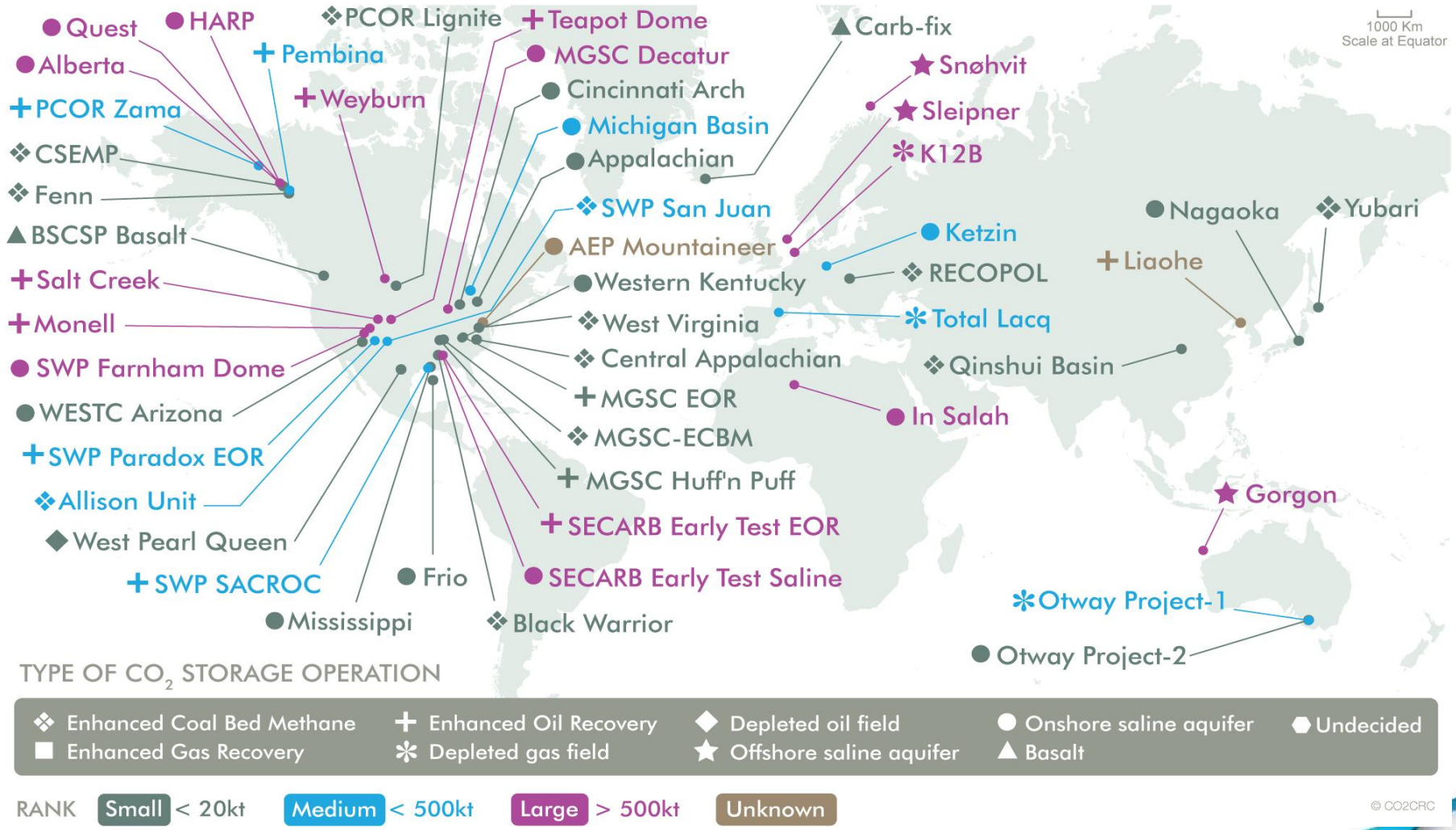
350km overland pipeline



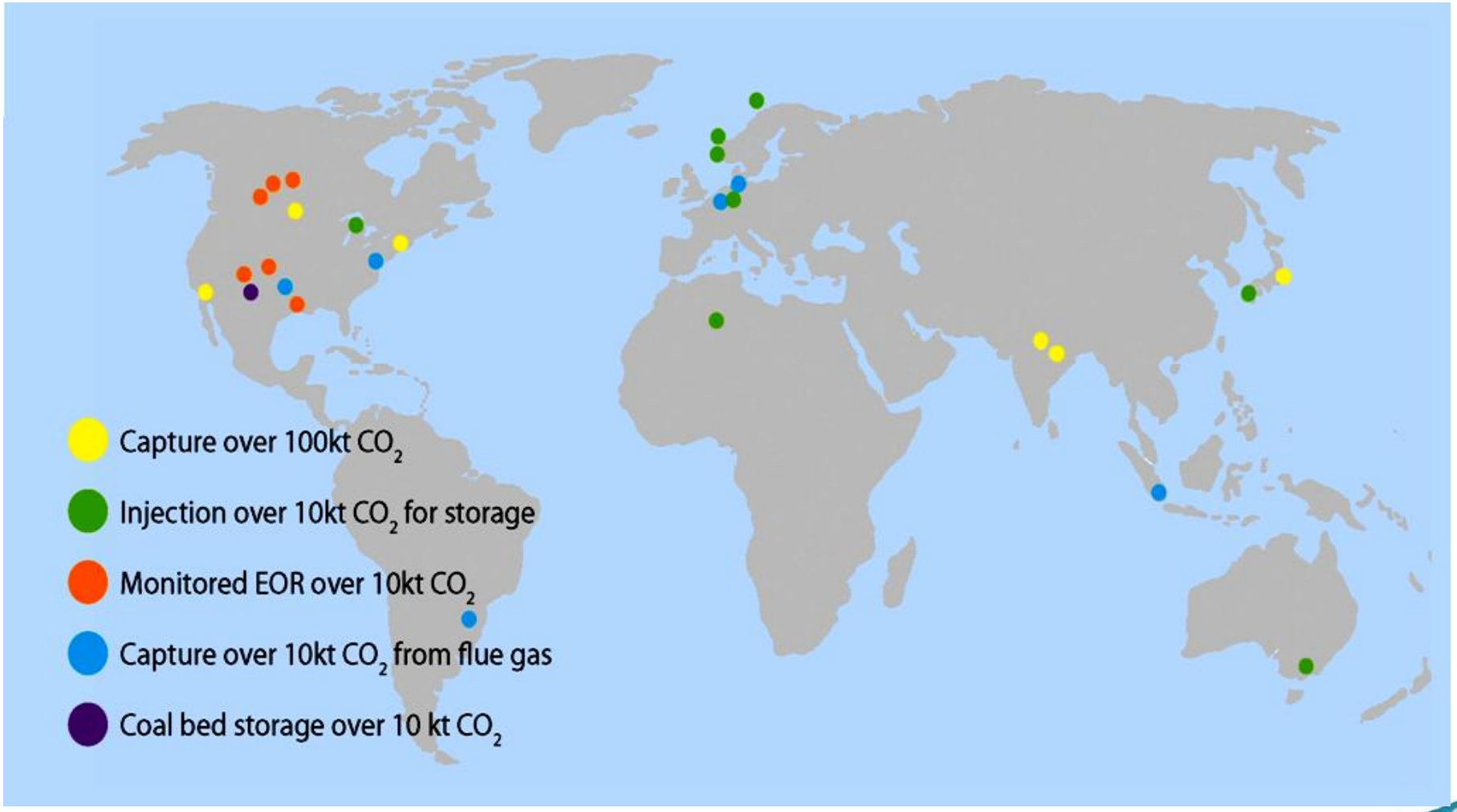
160km sub sea pipeline

1996 1998 **2000** 2002 **2004** 2006 **2008** 2010 2012 2014 2016 2018

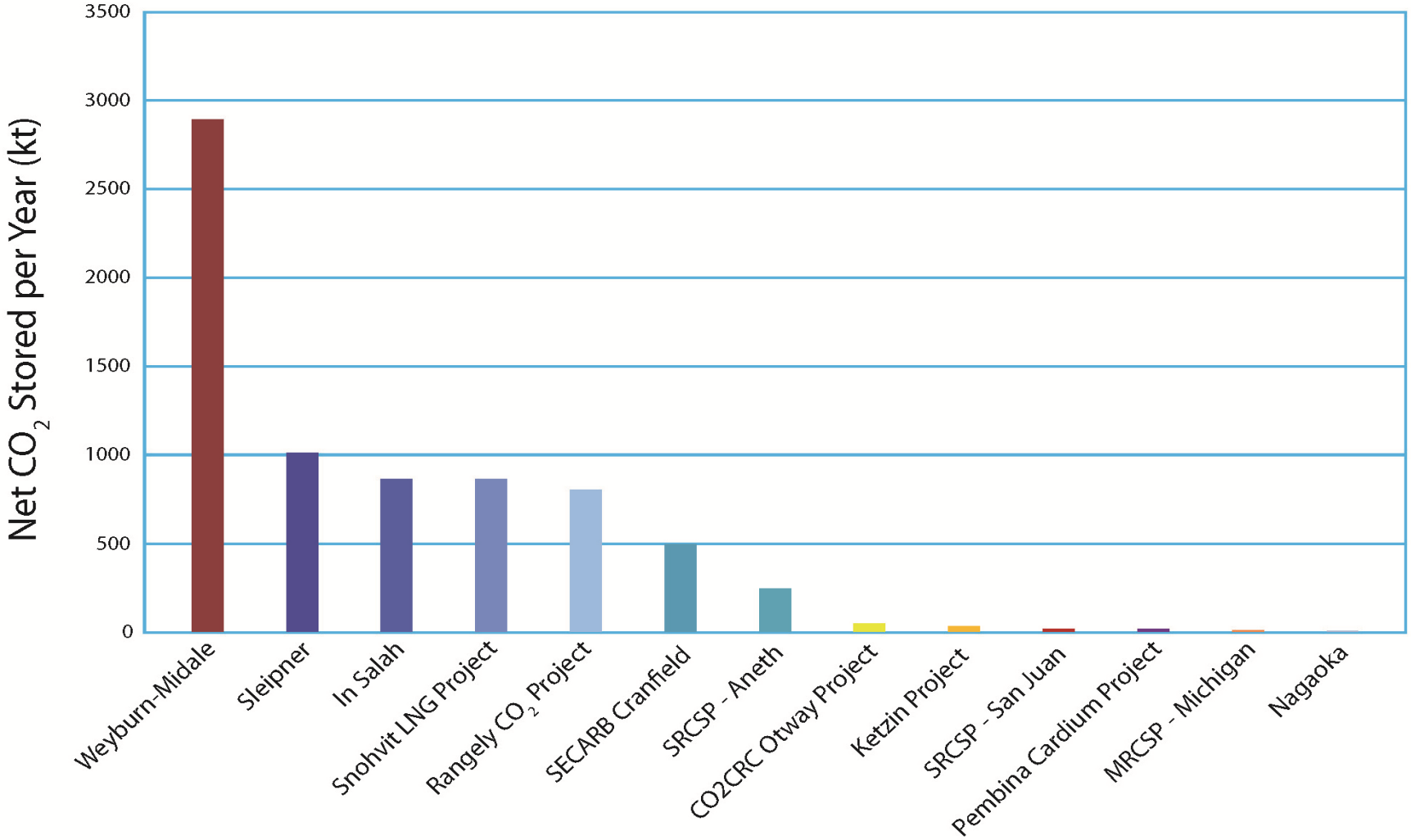
Current Storage Project Activity



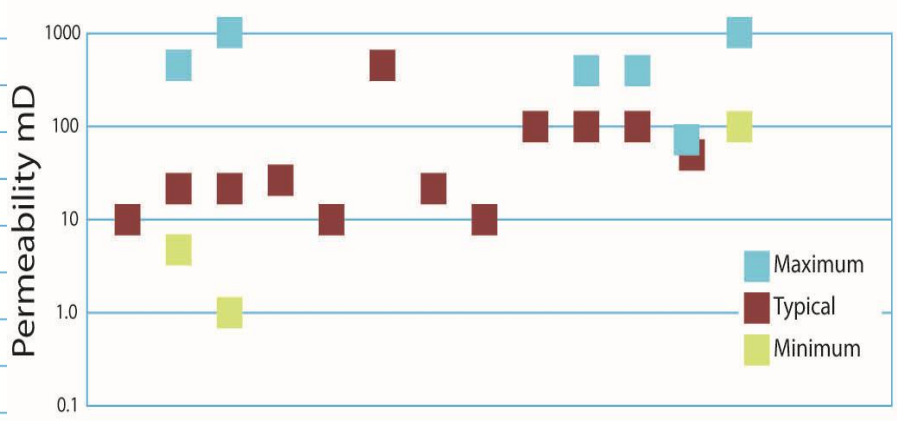
Project Locations

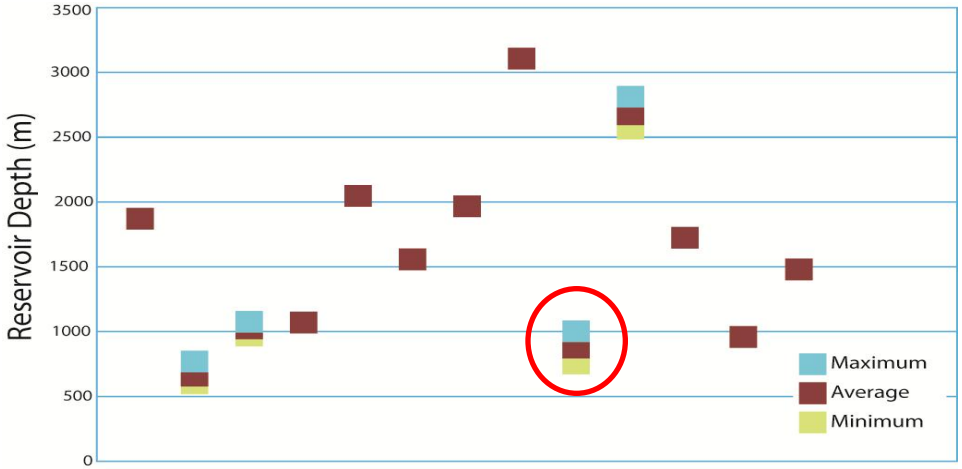


Storage rates



Storage Reservoir Characteristics

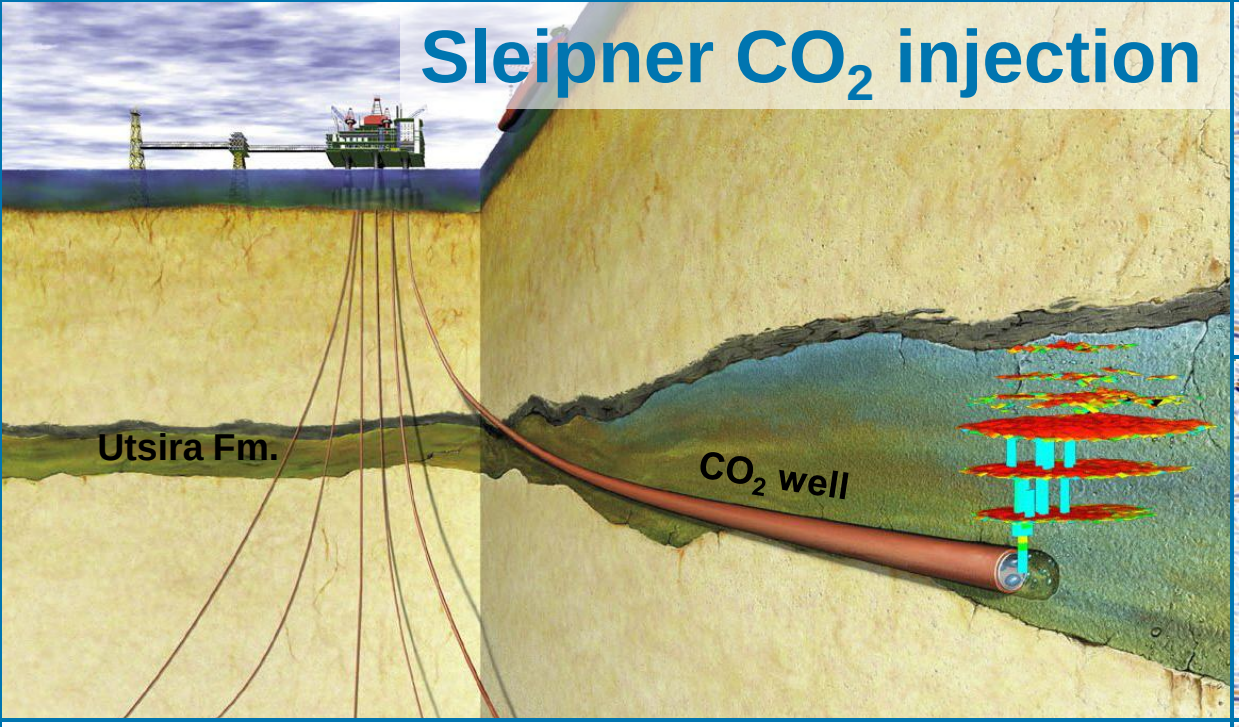




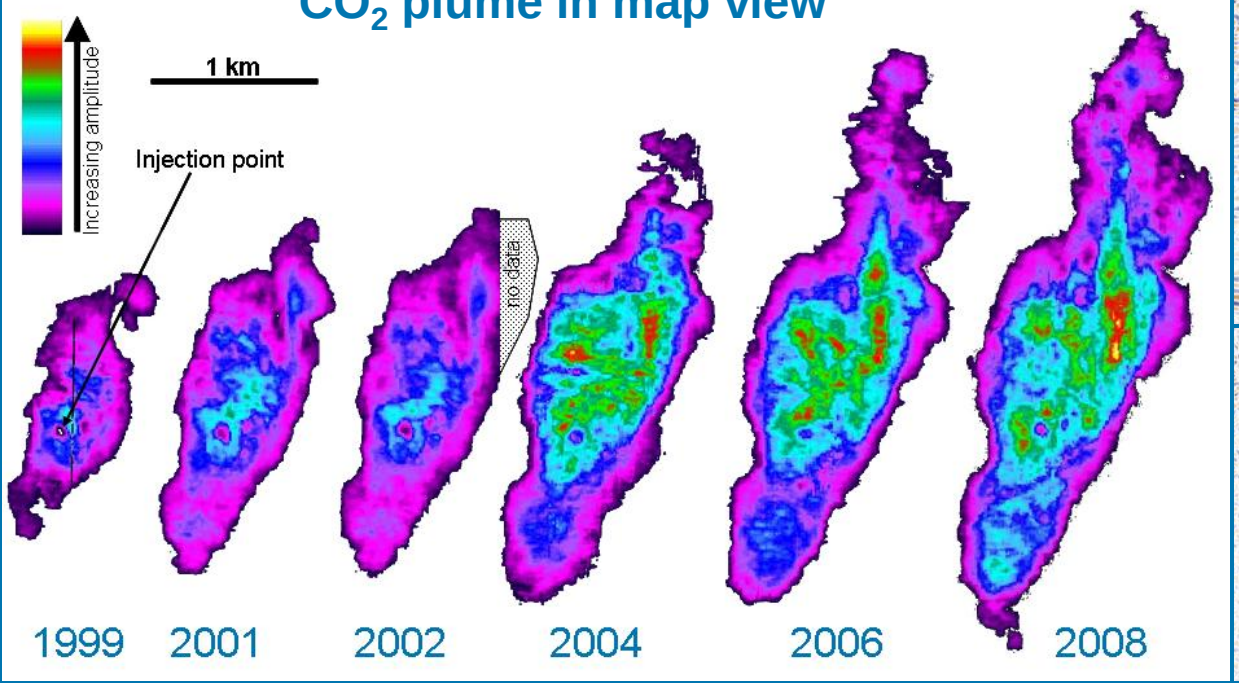
Sleipner

Unconfined sand body
High porosity
No pressure build up
Open system DSF

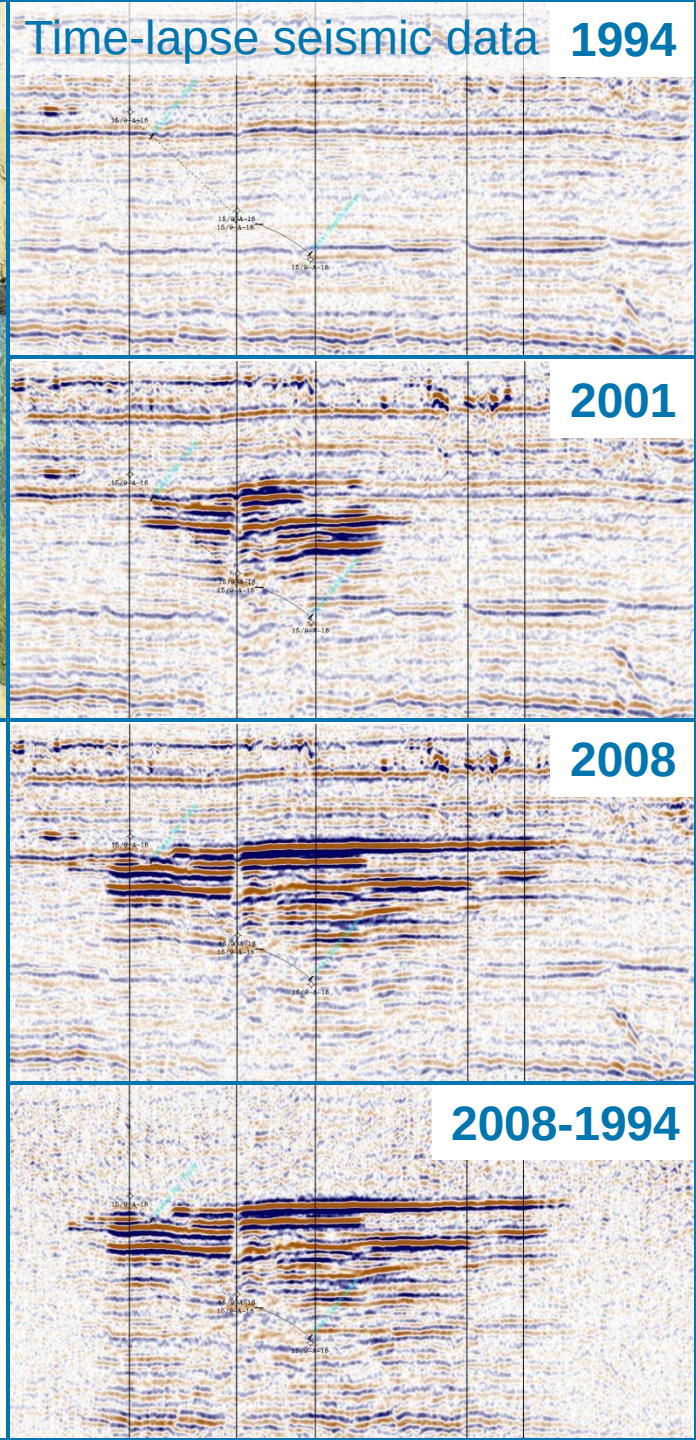
Sleipner CO_2 injection



CO_2 plume in map view



Time-lapse seismic data



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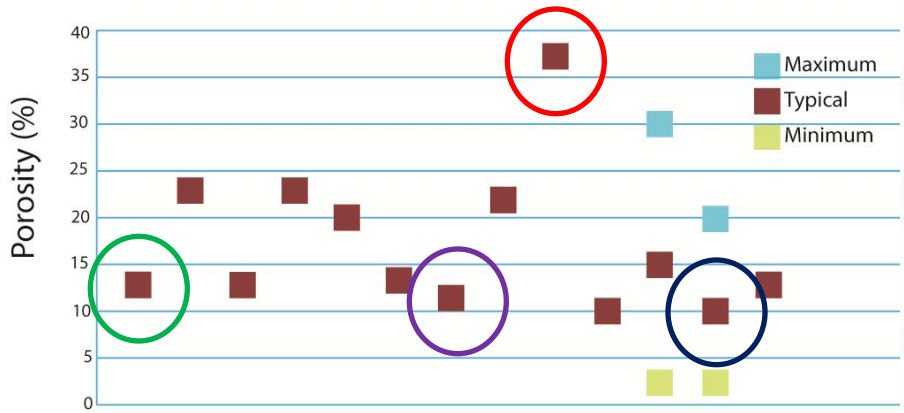
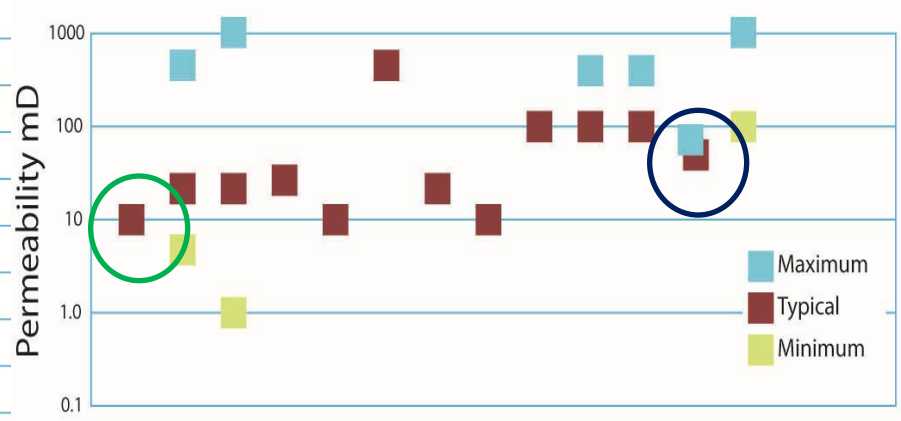
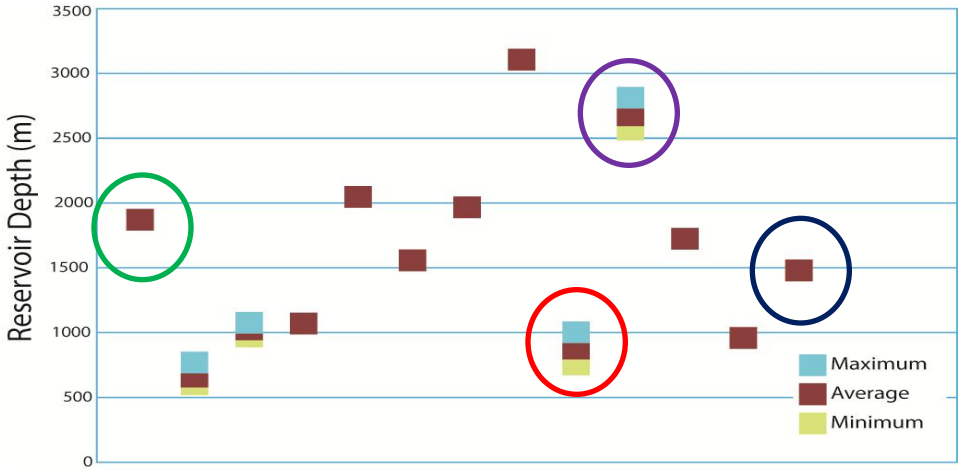






Sleipner – open system

Weyburn

In-Salah

Snohvit- closed system?

Injectivity

- CO_2 has been injected into:
  - High permeability sand bodies offshore (Sleipner)
  - Low permeability sandstone and carbonate reservoirs
    - On shore (In-Salah, Weyburn etc)
    - Off shore (K12-B)
  - Depths ranging from 800 to >3000m
- Some injection problems identified early at some sites
  - No insurmountable problems reported

Monitoring

Technique	No of Sites	Positive comments	Negative comments
DH temp/pressure	11		
Surface seismic	10	2	3
Soil gas	9		
Geochemical	8	1	
VSP	8		1
Microseismic	7		1
Gravity	4		1
Crosswell seismic	3	1	1
Electrical Conductivity	3	1	
Satellite	3	1	

Monitoring Experience

- Growing body of evidence to date
- No firm evidence from any of the large scale projects that leakage is occurring from the formation
  - Weyburn (~10years), Sleipner (~14 years), Rangeley (~25 years)
- Only one project has identified any surface seepage – Rangeley
  - Most recent results indicate CO_2 at surface is biologically converted from CH_4 microseepage
- Monitoring lifetimes are short <25 years, but knowledge is building
- Cannot quantify injection volumes or seepage rates at present - yet

Containment

- Literature in public domain suggesting release from Sleipner refuted
- Weyburn – seismic anomaly above immediate caprock but below regional caprock. Very small percentage of injected CO_2
- In-Salah – leakage through old well, not properly abandoned – remedial work successful

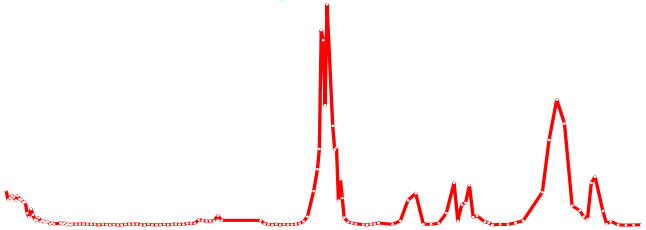
Leakage

- Natural analogues have been used to study environmental impacts of leakage along faults

The impact of the gas is limited. Schools of fish swim around the gas plume **Panarea, Italy. INGV**

Latera caldera

Ecosystems adapt



CO_2 flux - *leakage only at permeable points along faults*
Prof Lombardi. URS

The Case of Well Bores

- Early laboratory research indicated significant deterioration of Portland cement integrity after contact with CO_2/brine solutions
- Results did not concur with field sampling of well cements in contact with CO_2
- Several studies of Surface Casing Pressure problems
  - Gulf of Mexico, Canada
- Studies indicate initial completions are key to SCP issue
  - Direct relationship between price of oil and SCP in Canadian study
- Gulf of Mexico incident
- Belt and braces measure – CO_2 resistant cements
- Techniques available to remediate well leakage

Is it safe?

- A lot of evidence to suggest there are limited safety issues with CCS
  - Good engineering/operational practise
  - Effective regulatory procedures/controls
    - Ensure monitoring/safety and verification

Will it stay underground?

- Growing body of evidence to suggest it will stay there
  - The underground is not heterogeneous
  - The unexpected is part of the learning curve

Issues faced

- Who is going to map the worlds storage capacity
  - Consistent basis across all continents?
  - Considerable cost?
  - Exploration capacity?
- Technical issues
  - Effect of reservoir pressurisation and impact on storage capacity needs to be assessed
    - Pressure relief?
  - Need to be able to quantify leakage
  - Impacts on ground water resources?
  - Impurities?

Biggest Challenge

- Convincing the sceptics
- Public opinion has stopped a number of storage projects already
- Scientists need to learn how communicate with laymen
  - We have the answers, we need to get the message over clearly!!!

Thank you

Any Questions?