CCS: Risks and Impacts

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CCS – Africa Workshops

April 2010

Structure of Presentation

1. ***Introduction to risk assessment***
2. ***Properties of CO_2***
3. ***Risks associated with capture***
4. ***Risks associated with transport***
5. ***Geological storage risks***
   - *Performance assessment/predictive modelling*
   - *Potential impacts*
   - *Risk management (monitoring, mitigation)*
6. ***Conclusions***

1. Risk Assessment

Technical meaning of risk (probability, impact)

Risk assessments provide a structured approach to project evaluation

Part of a wider risk management process

Widely applied to industrial projects, environmental assessments, etc

2. Properties of CO_2 and associated substances

CO_2

Label 2.2 : Non flammable, non toxic gas.

SO_2

H_2S

Label 2.3 : Toxic gas.

Label 2.1 : flammab gas.

N : Dangerous for the environment

T+ : Very toxic

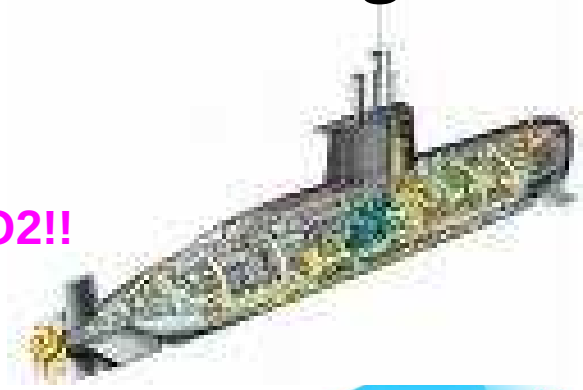
F+ : Extremely flammable

Impairment

CO_2 can be tolerated in quite high concentrations without permanent risk to health

BUT if those exposed have key tasks to execute their response may be impaired

THUS need to consider effects during emergency situations



Atmosphere in submarines is typically 4000ppm CO2!!
Just below the TLV. Crews should not be impaired.
However levels up to 10,000ppm are reported

3. CO_2 Capture Risks

- **The risk of scaling up the capture plants** (Will the capture process work on large scale? More demonstration projects are needed to eliminate this risk)
- **The risk of fully CCS integrated system and influence on the power plants:**
  - The power plant ability and flexibility to provide electricity without CO_2 capture (capture no capture option)
  - The risk of shutting down the whole power plant if a problem occurred in the capture plant (This might occur if the power plant is fully integrated with the capture process (e.g. pre combustion) or because it could not cope with the regulation of low CO_2 emissions anymore after the failure of the capture plant)
- **Specific technical risks per capture technology:**
  - Post combustion capture: solvent degradation and equipment corrosion
  - Oxy-fuel combustion capture: boiler operation (burner design, flue gas recycle, temperature control and preventing air-in leakage)
  - Pre-combustion capture: hydrogen rich turbines operation and availability
- **The risk of integrating the capture process to the power plant (e.g. steam extraction issues)**
- **Environmental impact: chemical emissions to air, water and land, and overall life cycle of the facility (e.g. increase fuel consumption)**

4. CO_2 Transport Hazards

Low temperature releases

High pressures

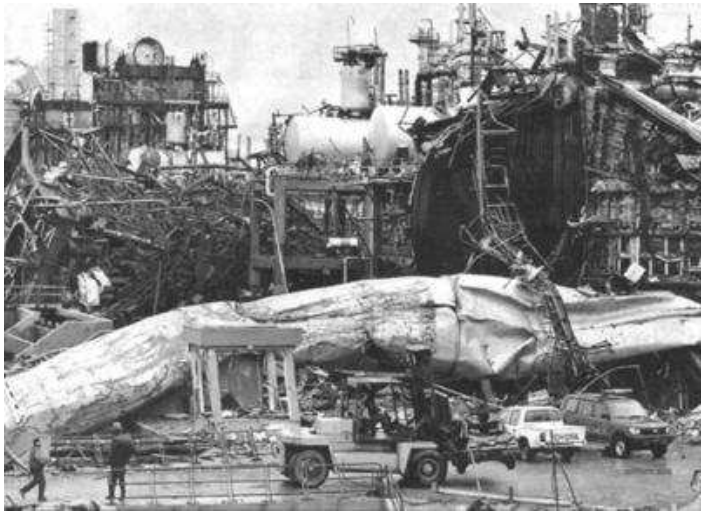
Corrosion

High vapour density

Detection issues

A running fracture – result of a test

Fractured gasoline line– undetected damage



Results of metal embrittlement

15th January 2009 Vancouver-line rupture

5. Geological Storage Risks

Predictive modelling of reservoir ('performance assessment'), leakage scenarios and potential subsurface impacts

Experiments and natural analogues used to assess potential impacts of leakage scenarios

Both elements combine for a storage risk assessment

Predictive Modelling

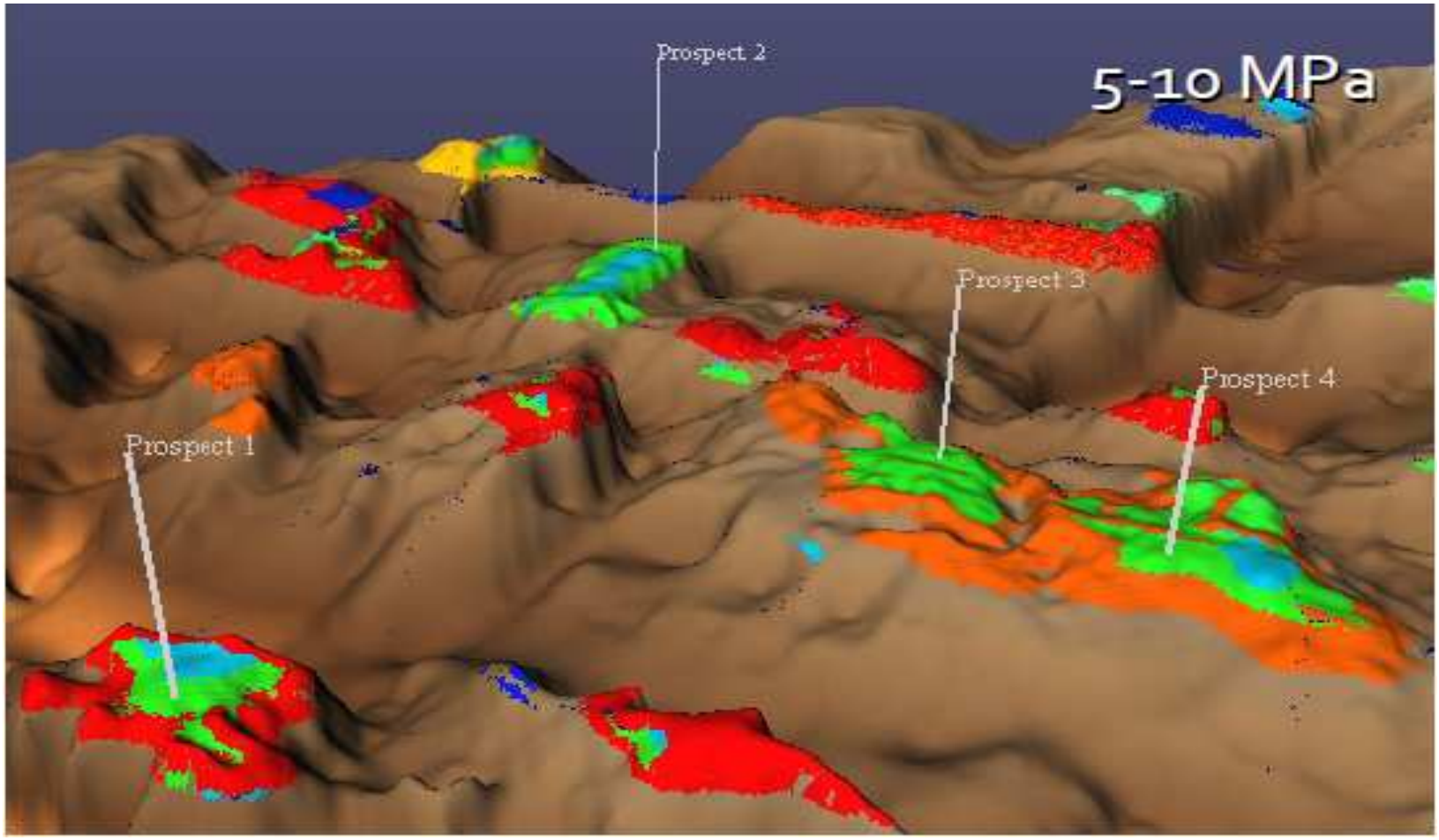
Can vary from simple analytical equations to complex numerical models

Based on knowledge from oil and gas industry, hydrogeology, theory

Knowledge gained from recent experimentation and early demonstration projects

Required by Regulators

Modelling Example



Courtesy Permedia Research

Modelling Challenges

Coupling of processes

Effects of other substances

Old/abandoned wells

Effects of pressurisation and fluid displacement

Calibration of models – need more real projects to provide monitoring data

Potential Impacts

Good site selection means minimal probability of leakage

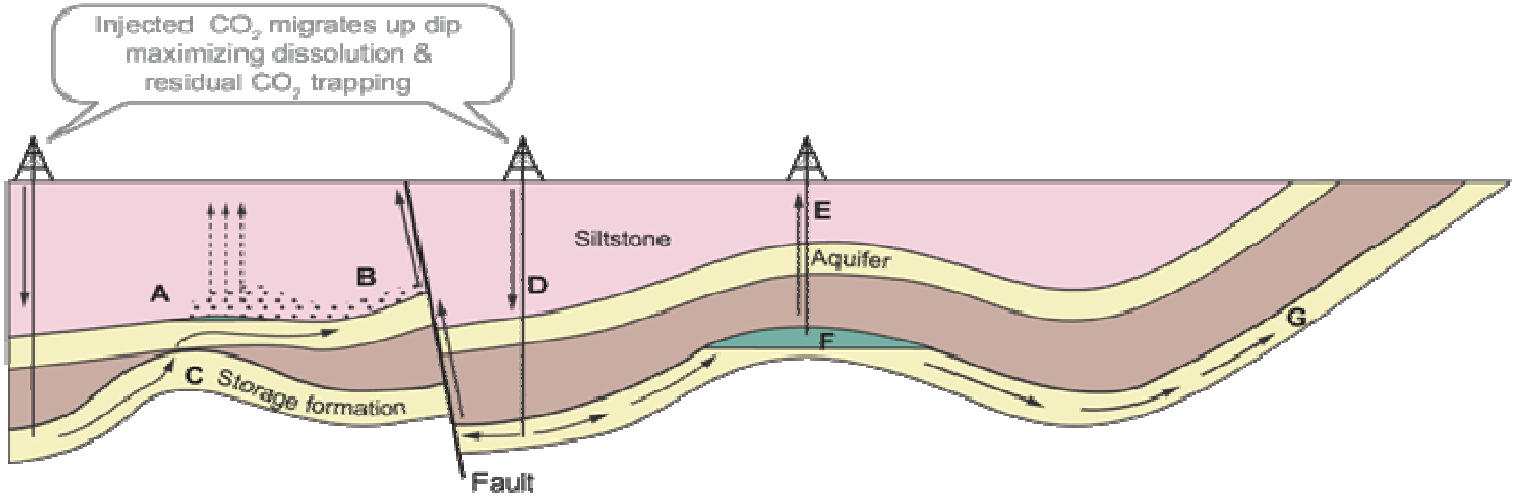
But need to know 'what if ?'……

Data from natural and industrial analogues

Laboratory experiments and models

Controlled field tests

Leakage Scenarios



Potential Escape Mechanisms

A. CO_2 gas pressure exceeds capillary pressure & passes through siltstone	**B.** Free CO_2 leaks from A into upper aquifer up fault	**C.** CO_2 escapes through 'gap' in cap rock into higher aquifer	**D.** Injected CO_2 migrates up dip, increases reservoir pressure & permeability of fault	**E.** CO_2 escapes via poorly plugged old abandoned well	**F.** Natural flow dissolves CO_2 at CO_2 / water interface & transports it out of closure	**G.** Dissolved CO_2 escapes to atmosphere or ocean

Remedial Measures

A. *Extract & purify ground-water*	***B.*** *Extract & purify ground-water*	***C.*** *Remove CO_2 & reinject elsewhere*	***D.*** *Lower injection rates or pressures*	***E.*** *Re-plug well with cement*	***F.*** *Intercept & reinject CO_2*	***G.*** *Intercept & reinject CO_2*

IPCC, 2005

University of Nottingham

The Latera caldera

Prof Lombardi. URS

The Latera caldera is about 150 km NW of Rome
Gas seeps occur throughout the heavily cultivated valley

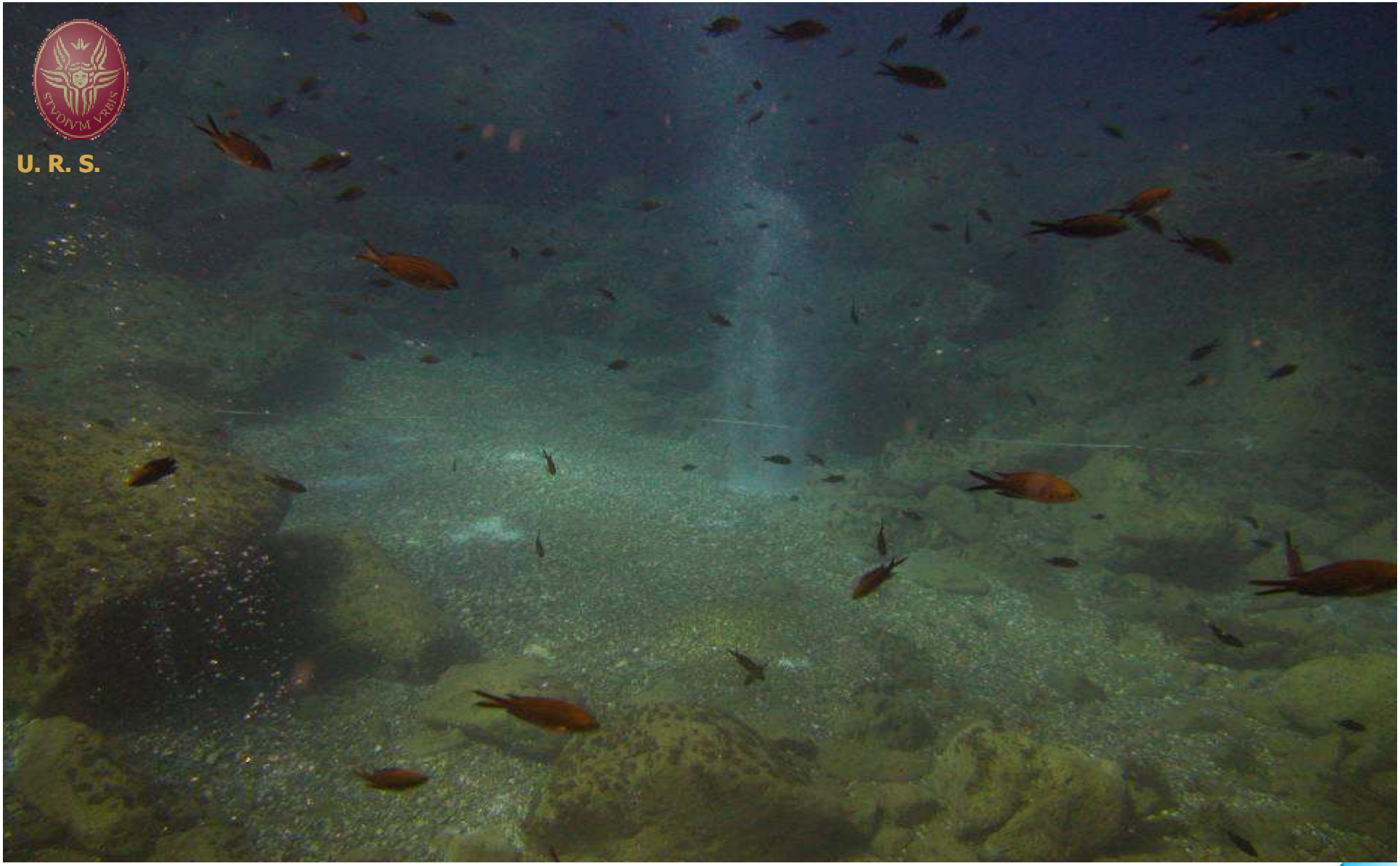
Latera –leakage pathways

CO_2 flux - *leakage only at permeable points along faults*

U. R. S.

Panarea, Italy. Prof Lombardi. URS

U. R. S.



The impact of the gas is limited. Schools of fish swim around the gas plume

Panarea, Italy. Prof Lombardi. URS

Crystal Geyser, Utah, USA

Monitoring and Mitigation

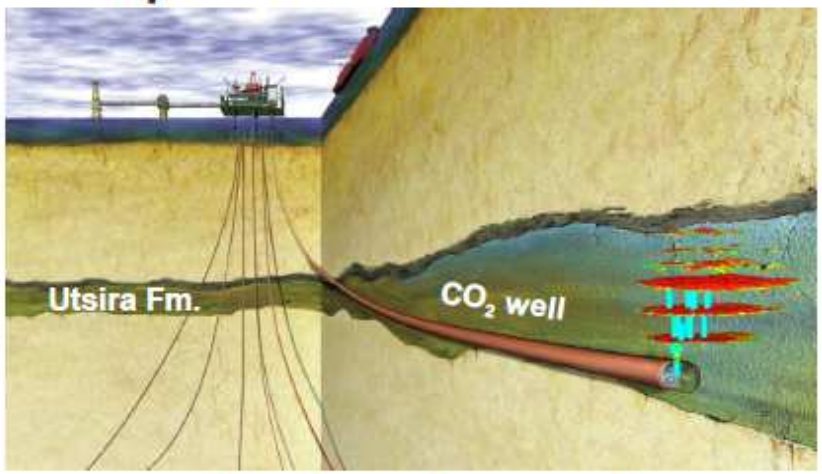
Monitoring techniques established and demonstrated

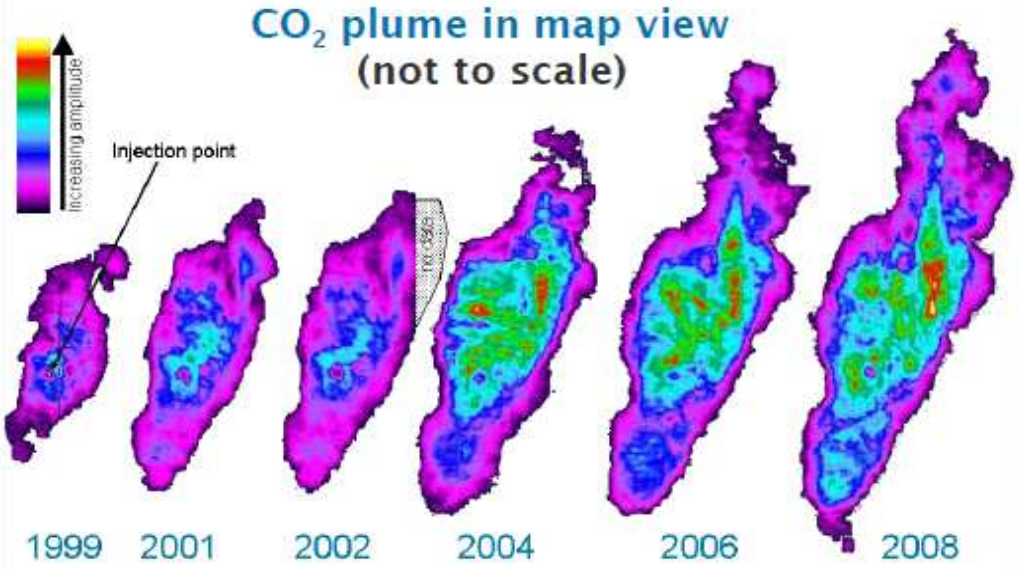
Monitoring provides stakeholder reassurance and regulatory compliance

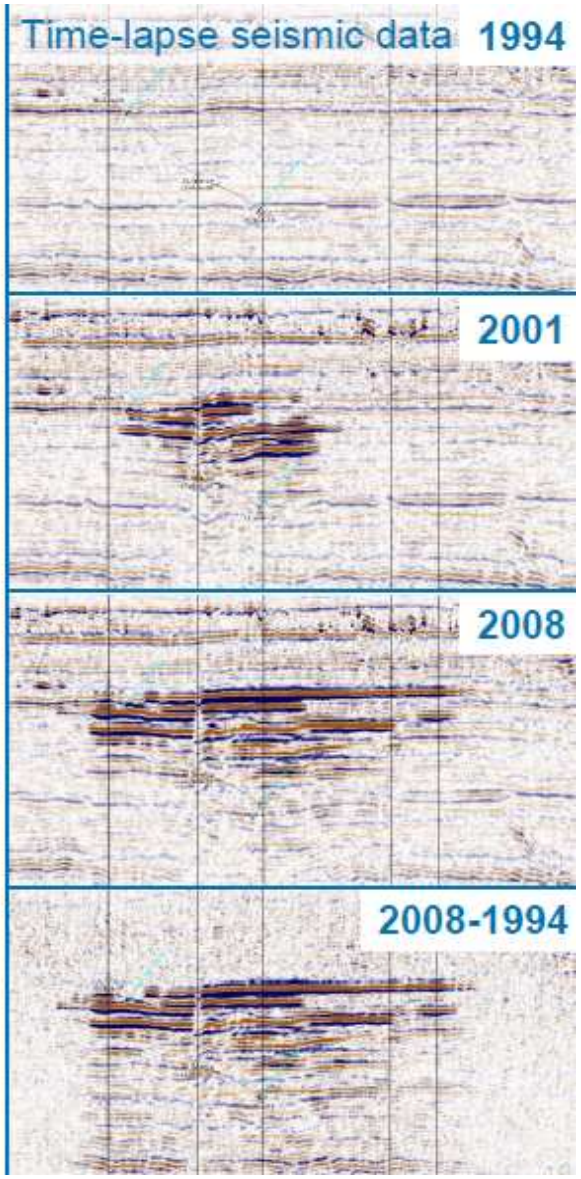
Mitigation strategies will be site-specific

Experience from CO2-EOR industry

Sleipner: An Overview







Courtesy Statoil

6. Conclusions

Capture and transport risks can be managed with existing engineering knowledge

Geological storage risks are site-specific

Predictive models provide performance assessment

Monitoring provides model calibration

Analogues provide information on potential impacts

Thank you for your attention