Australian Government
Geoscience Australia

CARBON CAPTURE AND GEOLOGICAL STORAGE
An Overview

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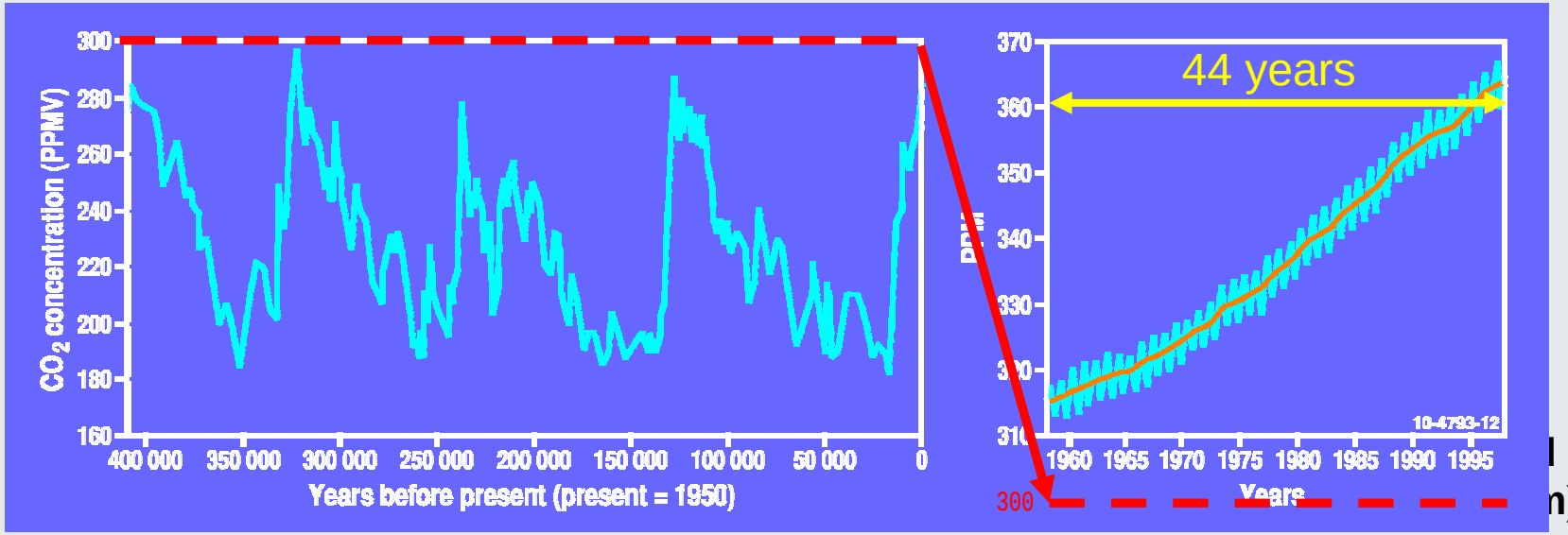
Wuhan, Hubei Province, PRC
Oct 30th - Nov 3rd 2010

Key Messages

1. Evidence from petroleum studies show that oil, gas and CO_2 can be stored in the deep subsurface for geological time
2. CO_2 can be stored in depleted oil and gas fields and deep saline formations
3. CO_2 injected as a fluid into reservoirs (sandstones) is trapped by seals (mudstones)
4. The technology for the geological storage of CO_2 is mature

The greenhouse gas problem

More Recent Times



400 000 years

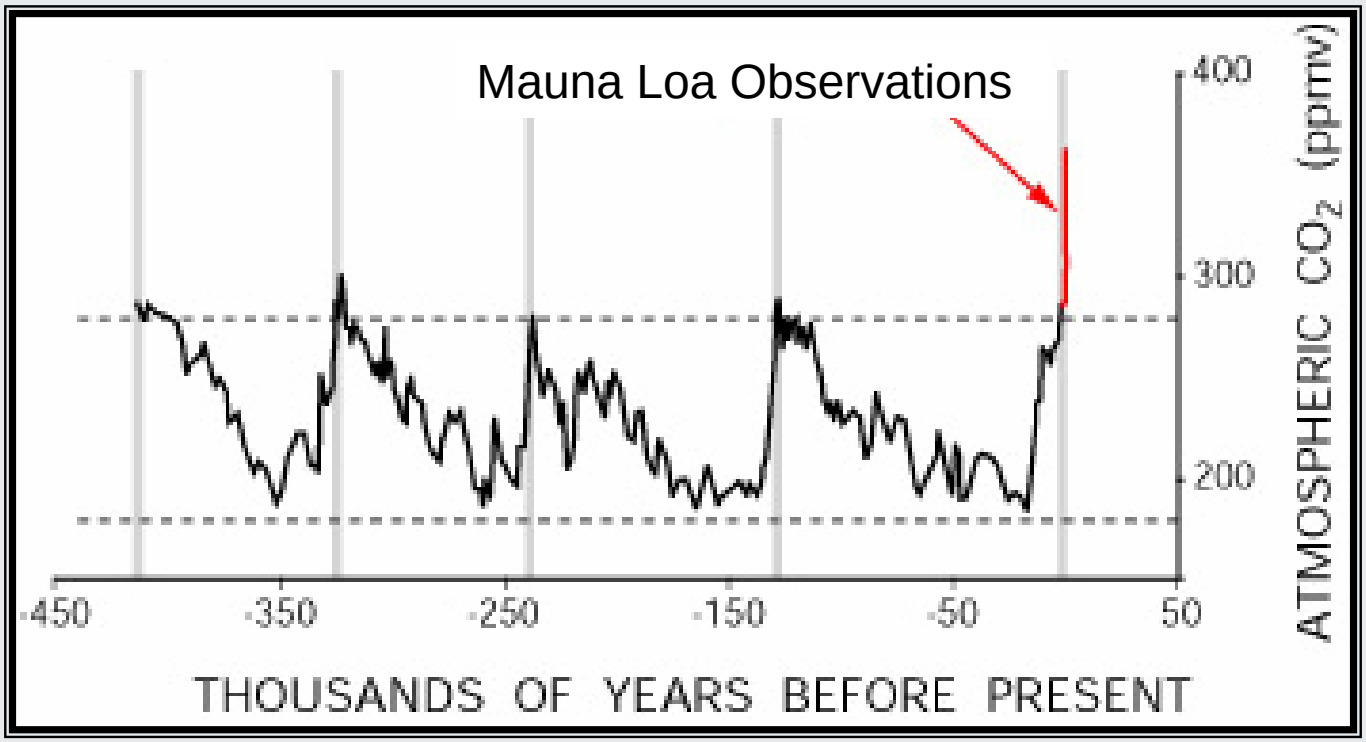
16% increase (60 ppm) of CO_2 concentrations in last 44 years

Concentration of CO_2 in atmosphere from Mauna Loa Observatory : 1959 - 2003

Currently 1.5 – 2.5ppm increase per year

[adapted from Carbon Mitigation Initiative, Princeton University]

If we put these two graphs together the effect is dramatic

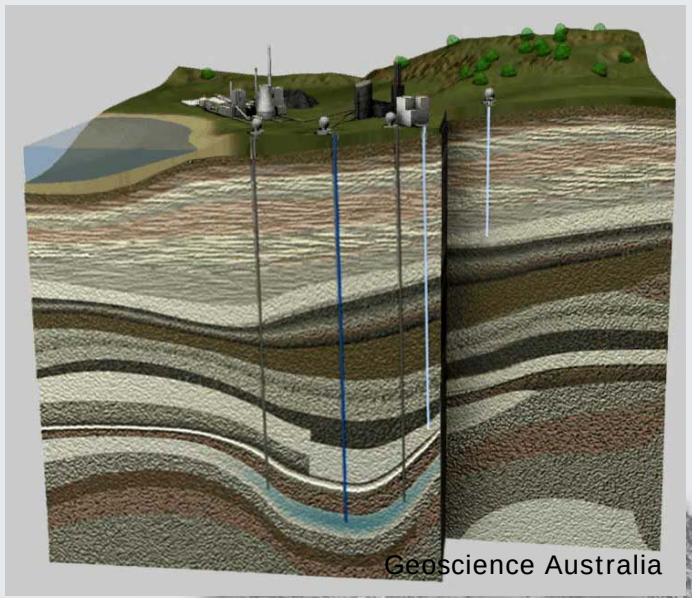


Unless they are controlled CO_2 levels in the atmosphere are heading to levels not seen since the Cretaceous

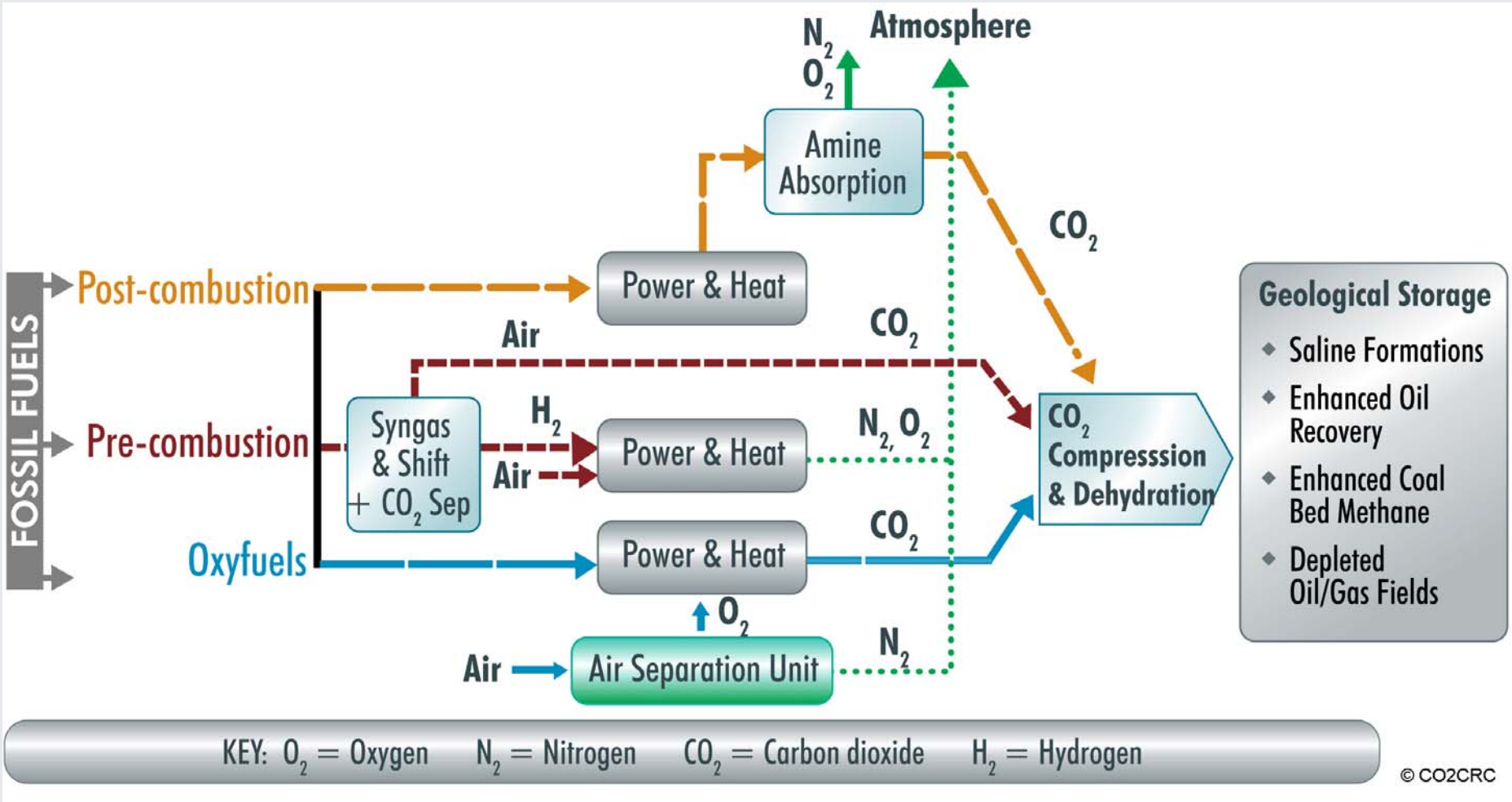
(Diagram source uncertain)

What is Carbon Capture and Storage?

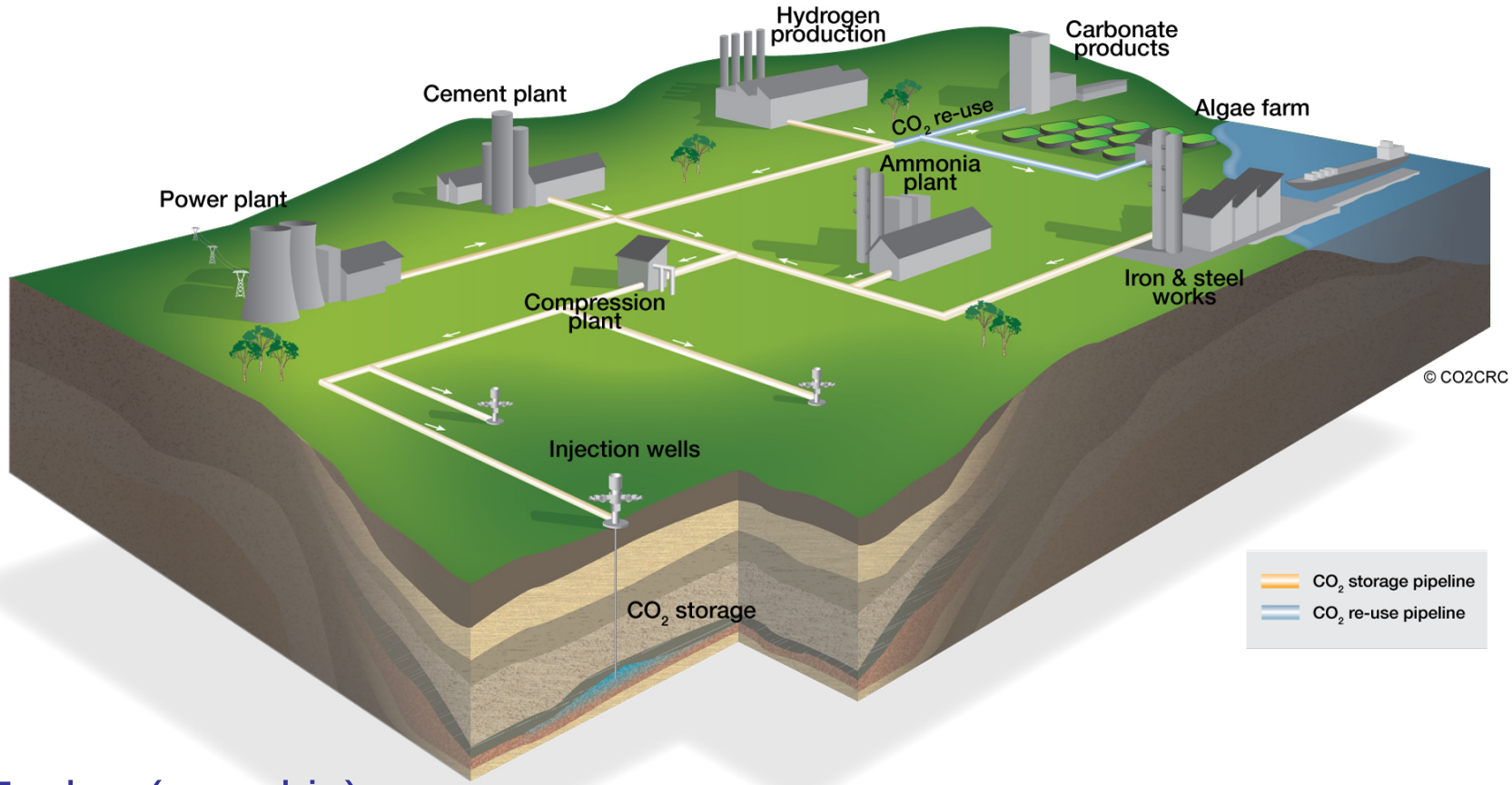
- Capture from stationary source – e.g. Power plant
- Transport to a storage site (pipeline)
- Injection via a well bore into a deep geological formation as a supercritical fluid
- Monitoring the migration of the fluid under buoyancy away from the injection point
- Eventual permanent trapping - structural, dissolution, residual and geochemical



Capture processes

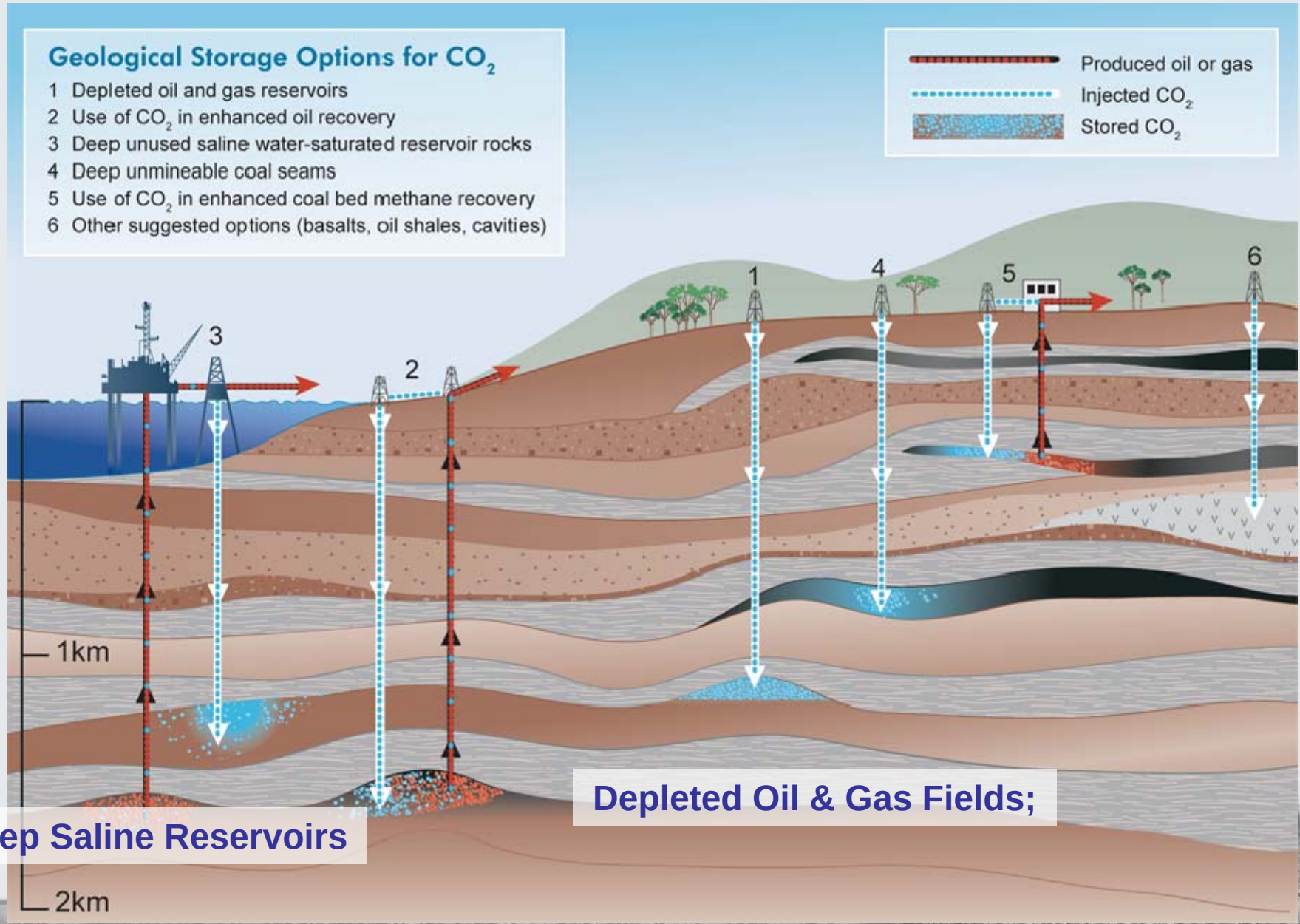


Emission sources and transport



- Tanker (e.g. ship)
- Pipeline
  - 5,650km of high-pressure CO_2 pipelines in North America

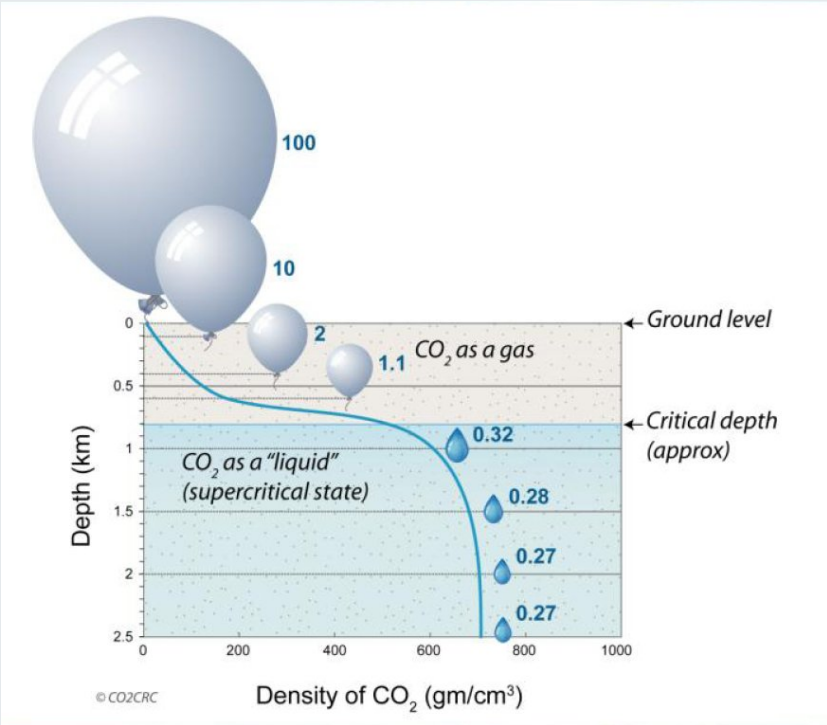
Options for Geological Storage



Source IPCC

Why Supercritical CO_2

- At Pressures higher than 7.39 MPa and Temperatures higher than 31.1°C, CO_2 becomes a supercritcal fluid: gas like but with 400x the density.
- Generally these conditions are found below about 800m in the subsurface



Source CO2CRC

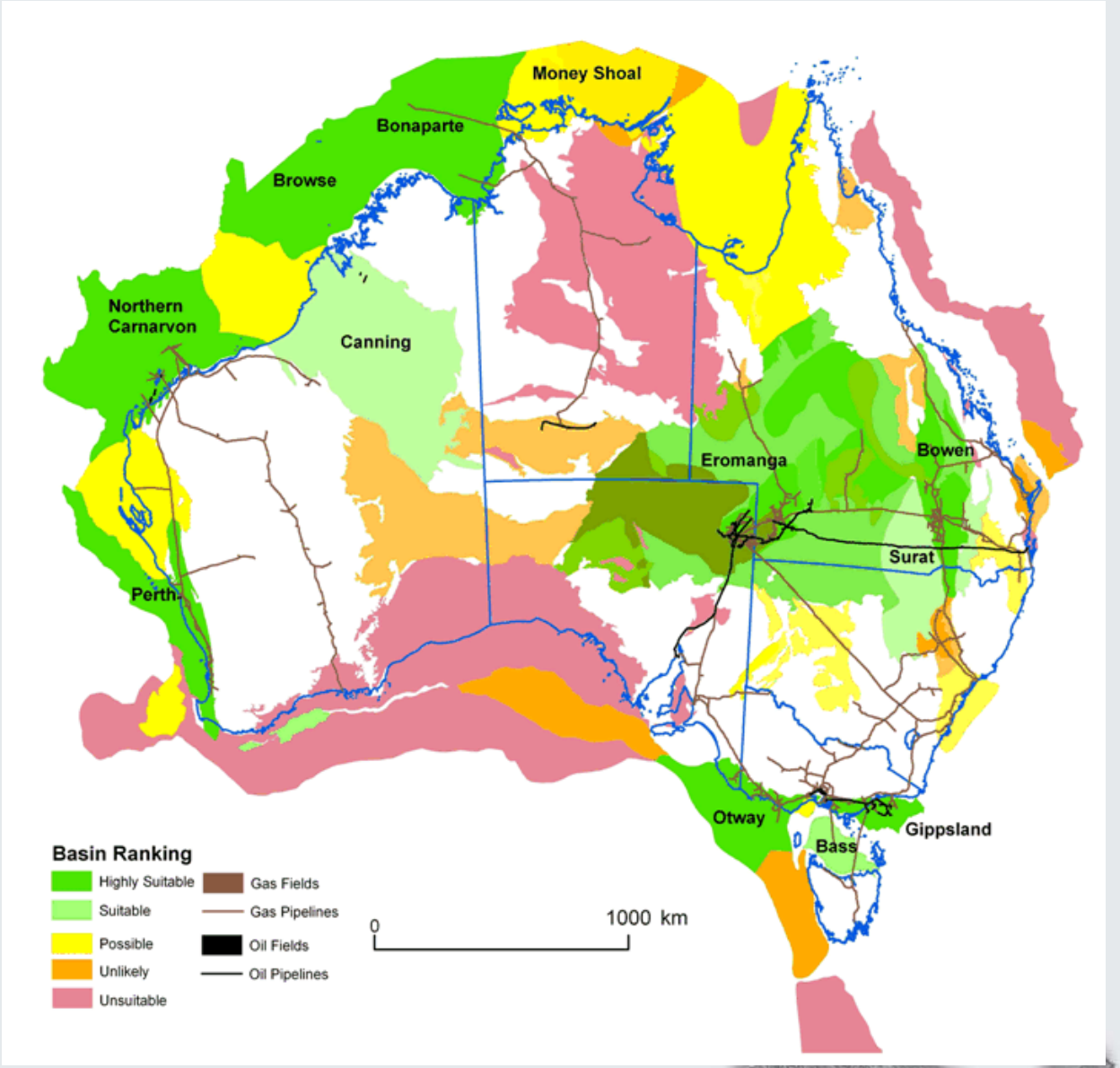
Sedimentary basins and geological storage

- Saline aquifers suitable for storage occur almost exclusively in sedimentary basins
- These are depressions in the crust of the earth in which sediments have accumulated over millions of years and which have not experienced significant uplift and folding
- They may be tens of kilometres thick and occur both on the continents and under ‘shallow seas
- All oil and gas accumulations occur in sedimentary basins.

Basins are not Equal

- Sedimentary basins are the regions that offer the opportunity for geological storage of CO_2.
- But all sedimentary basins do not have the same potential for storage
- We need to consider the tectonic settings and reservoir characteristics of each basin

An example of the ranking of basins for carbon dioxide storage from a recent Australian Government Study conducted by Geoscience Australia

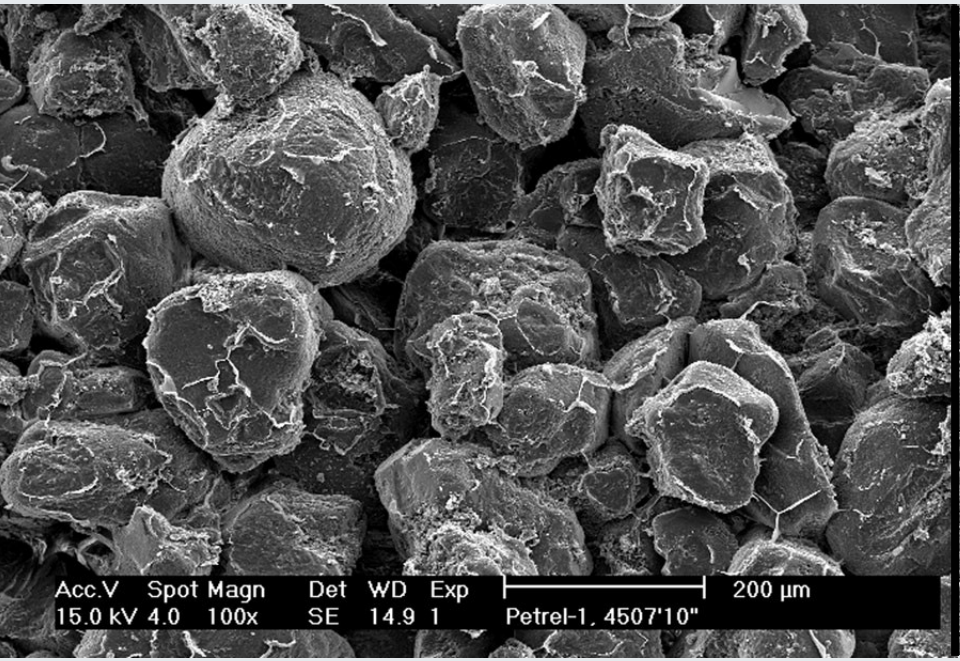


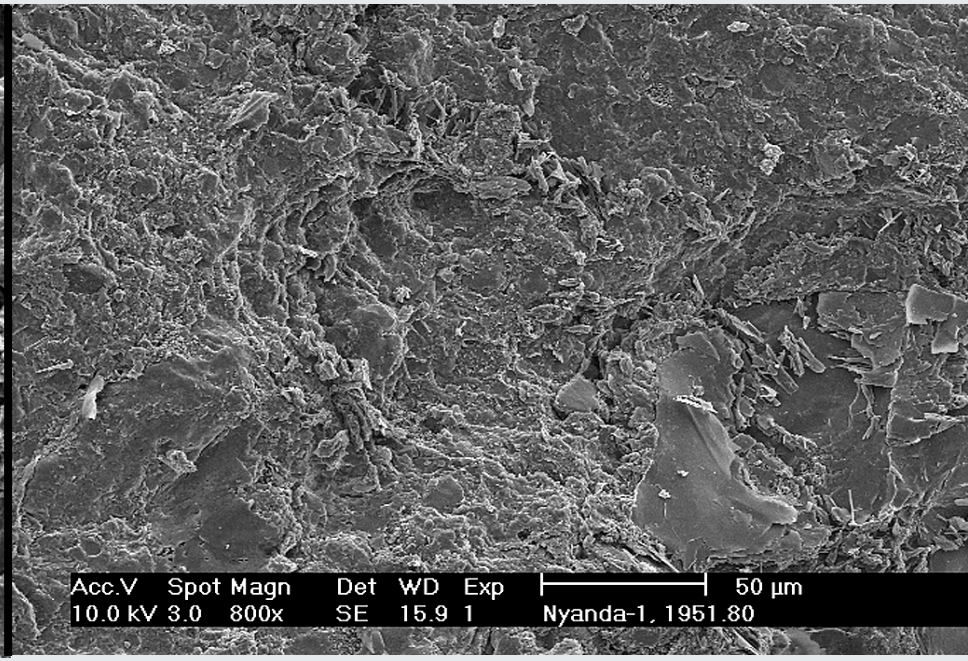
Reservoirs and Seals

- Reservoir rocks have spaces (pores) between the grains which can hold fluids and connections between the pores which can allow the fluids to flow through them (permeability) e.g. sandstones and limestones.

- Sealing rocks are very fine grained with not practical permeability e.g. mudstones or shales.

Reservoir v Seal





~1 millimetre

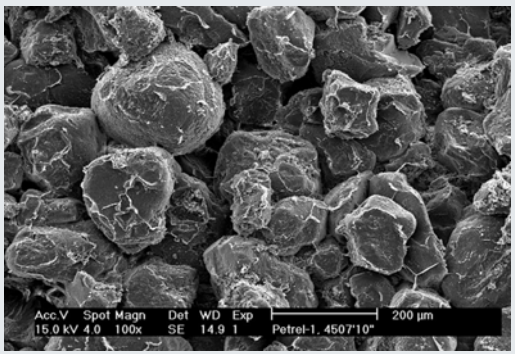
(Container)

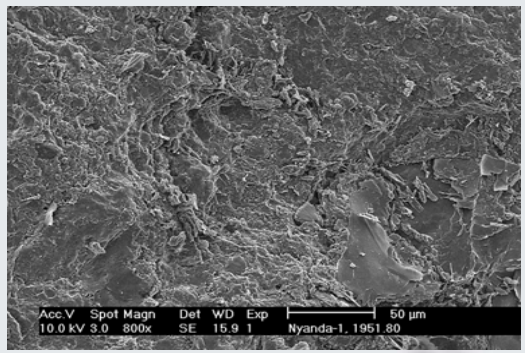
~¼ millimetre

(Lid)

Reservoirs and Seals

- Where a sealing rock overlies a porous reservoir rock the seal is able to prevent buoyant fluids such as oil gas or carbon dioxide from rising out of the reservoir.



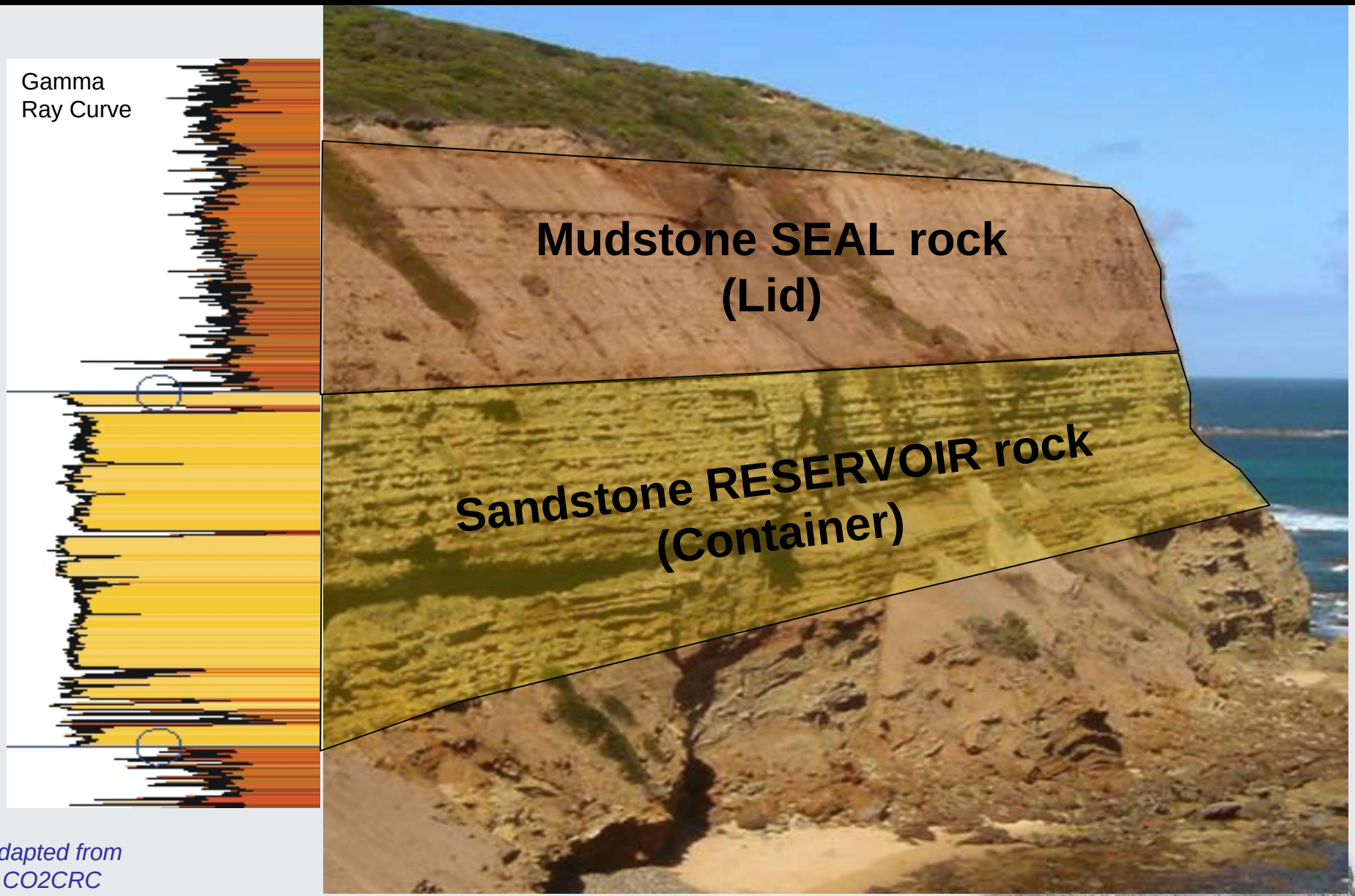


How can you store anything in rock?

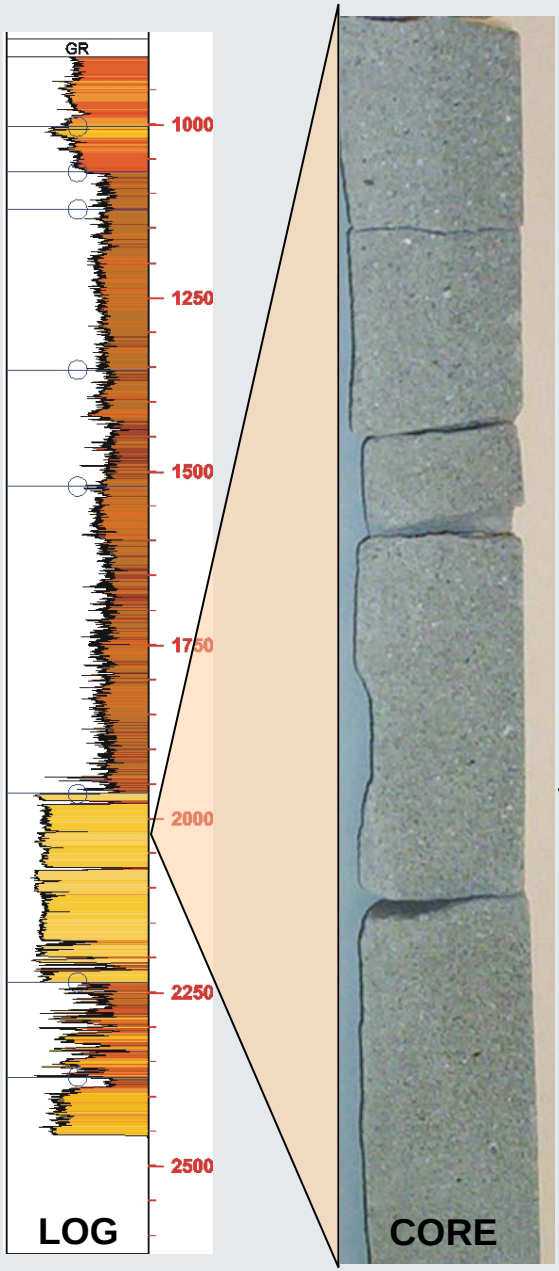
The geological characteristics of the subsurface can be seen exposed in coastal outcrops

Adapted from CO2CRC

How can you store anything in rock?



Adapted from CO2CRC



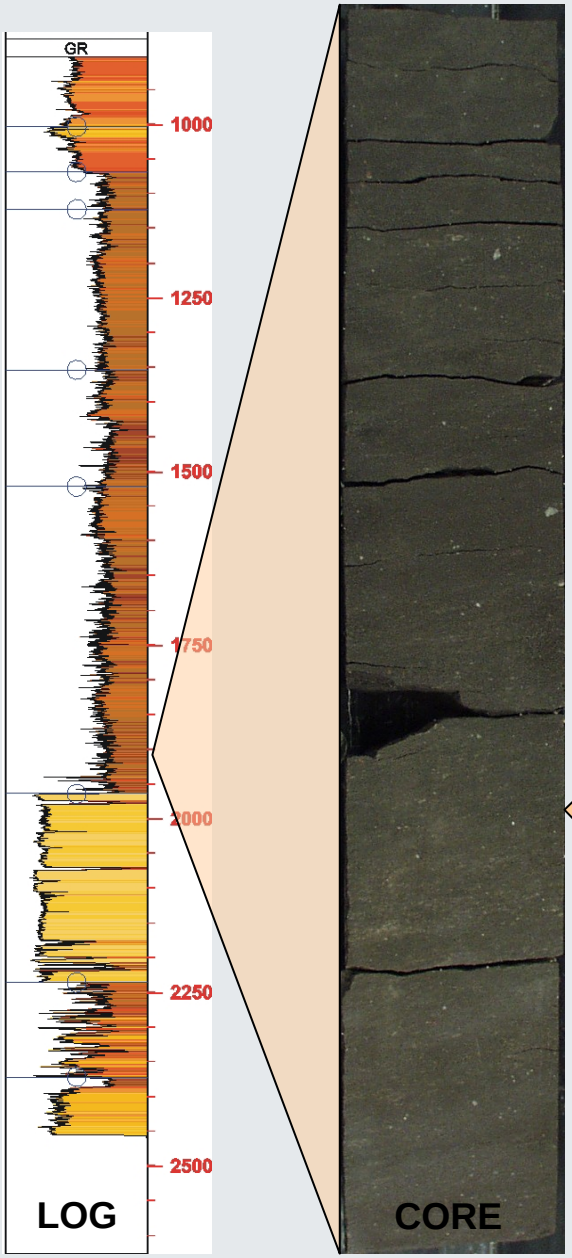
What is a Reservoir Rock?

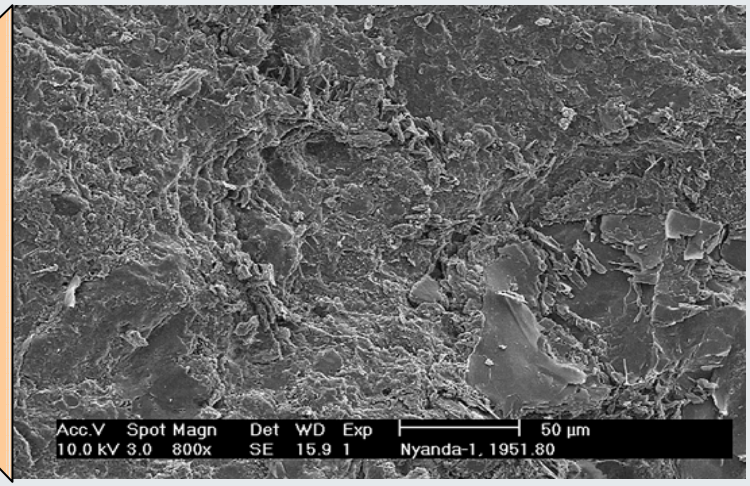
- Porous – spaces between grains
- Permeable – allows fluid flow
- Contains water, sometimes oil or gas
- E.g. sandstone
- NOT a large void

Approximately 1mm

What is a Sealing Rock?

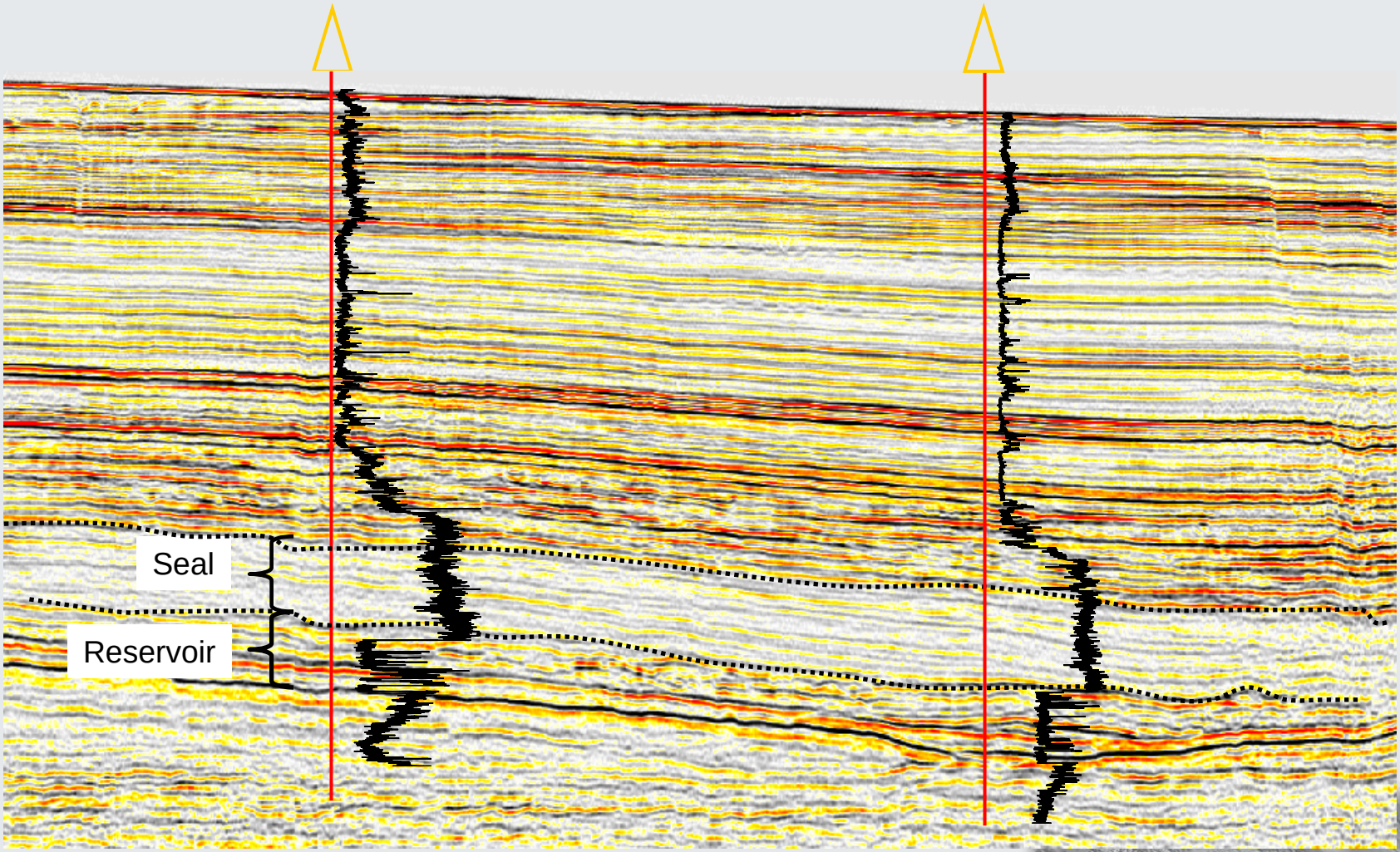
- Impermeable – prevents fluid flow
- E.g. mudstone





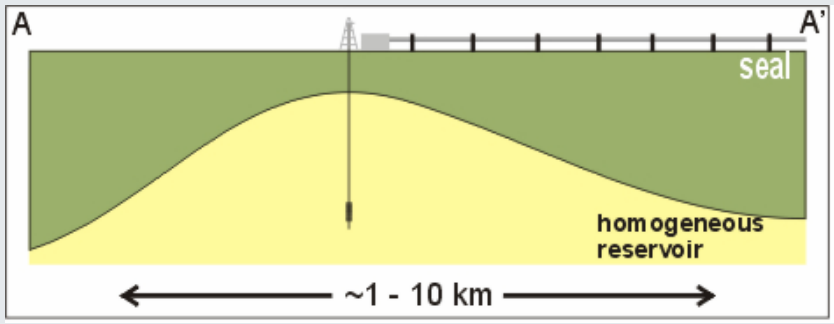
¼ millimetre

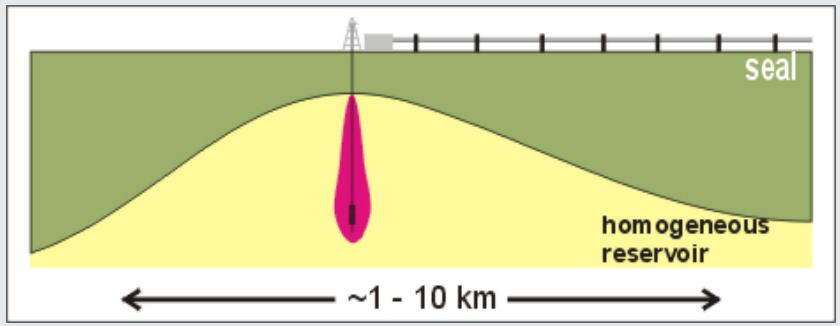
Seismic Identification

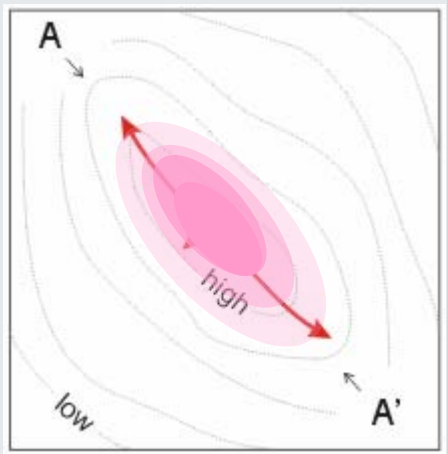


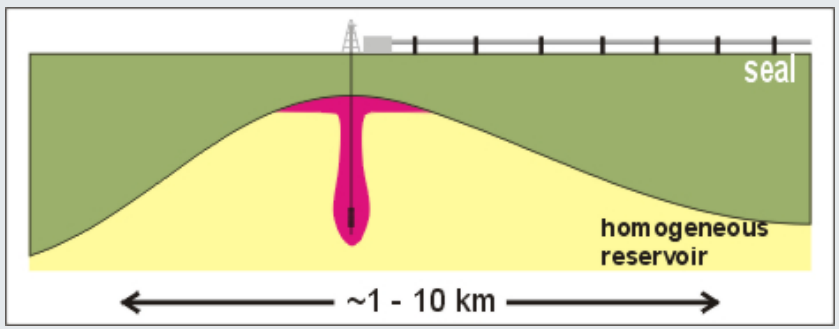
Storage Mechanisms

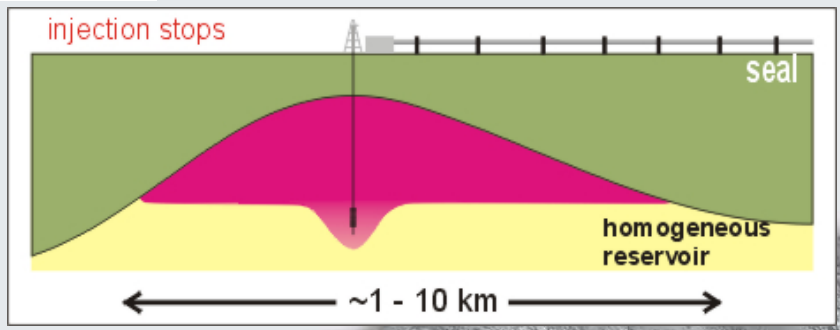
Structural Traps



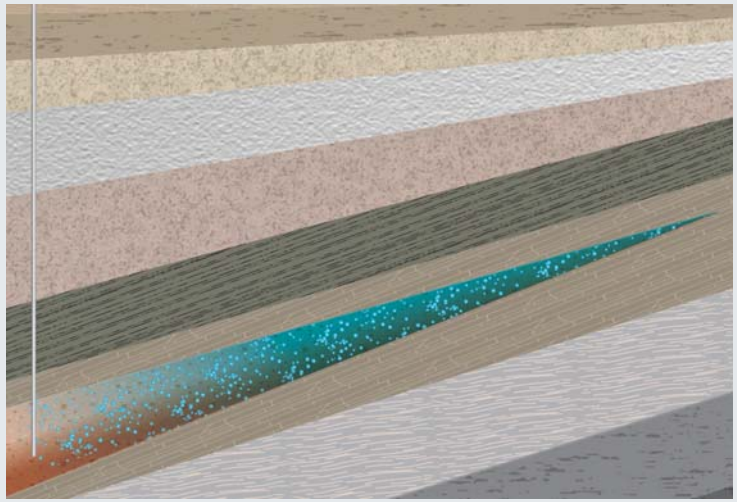


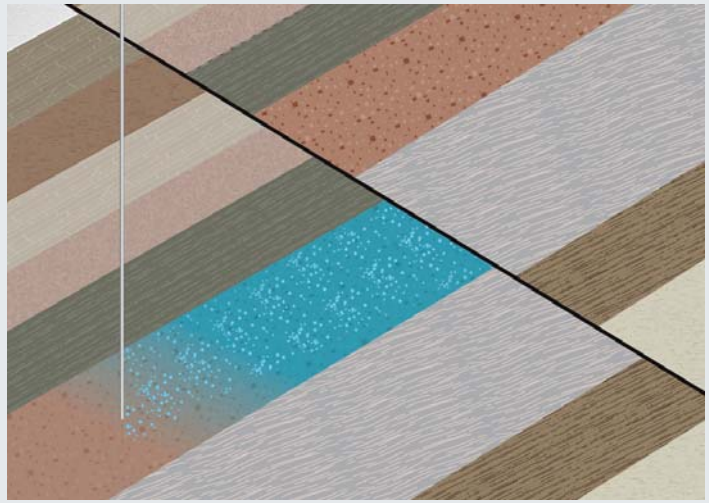


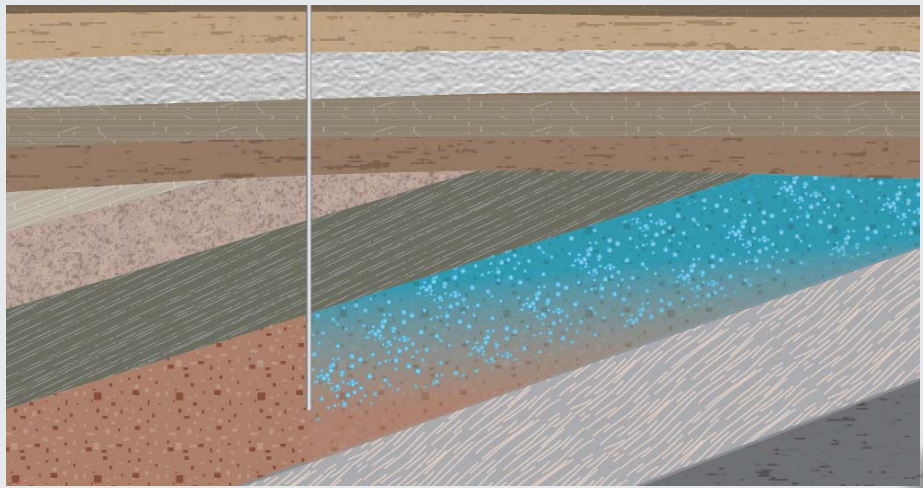




Conceptual CO_2 Storage Scenarios

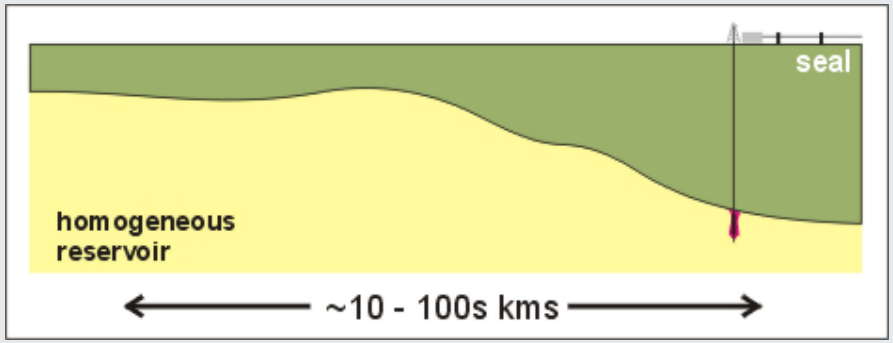


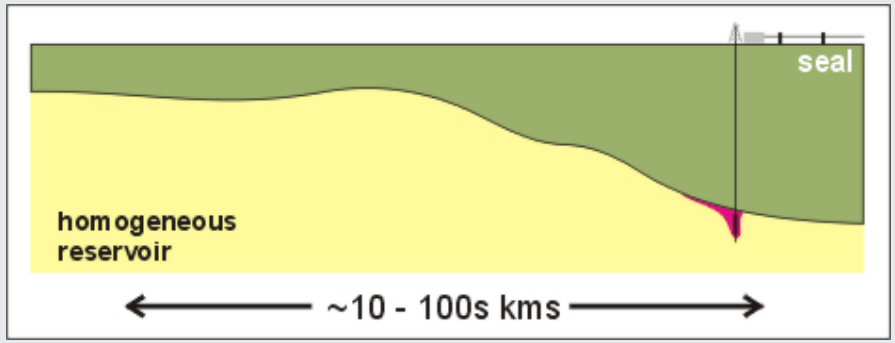


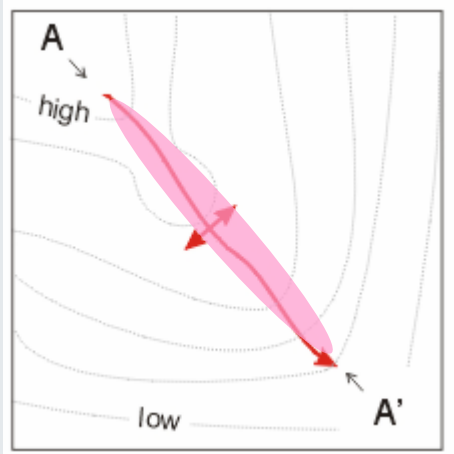


Source: CO2CRC

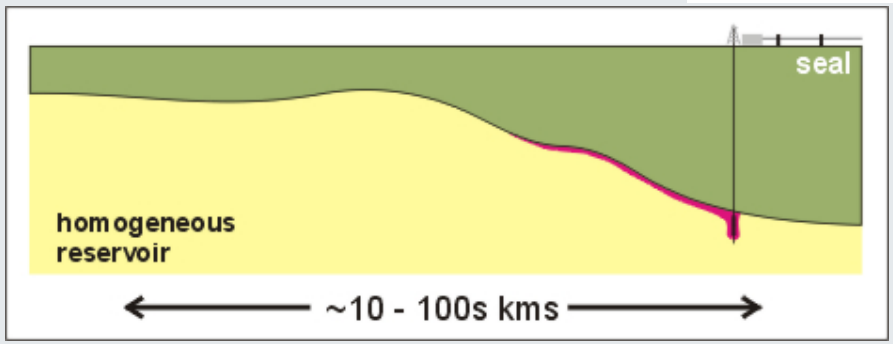
Storage Mechanisms
Saline Reservoir Trapping

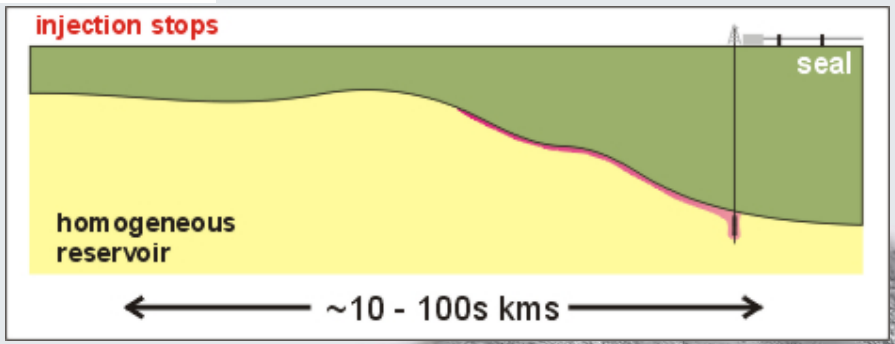






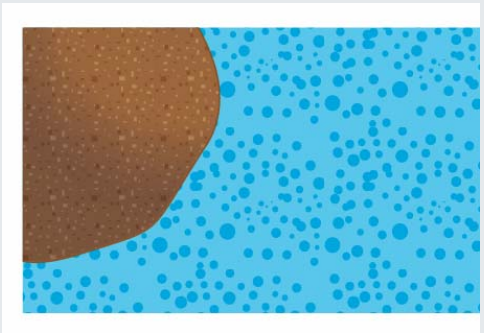
Trap Structure



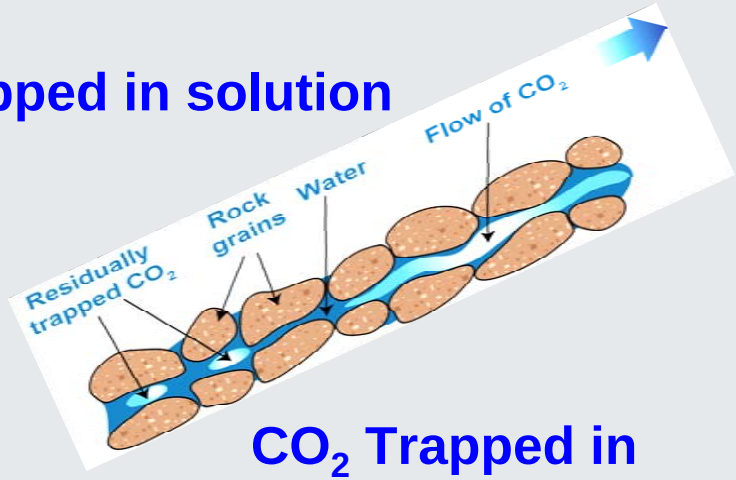


(Slide courtesy of Robert Root)

Saline Reservoir Trapping



CO_2 Trapped in solution



CO_2 Trapped in rock pores as Residual Saturation

CO_2 Trapped as a mineral

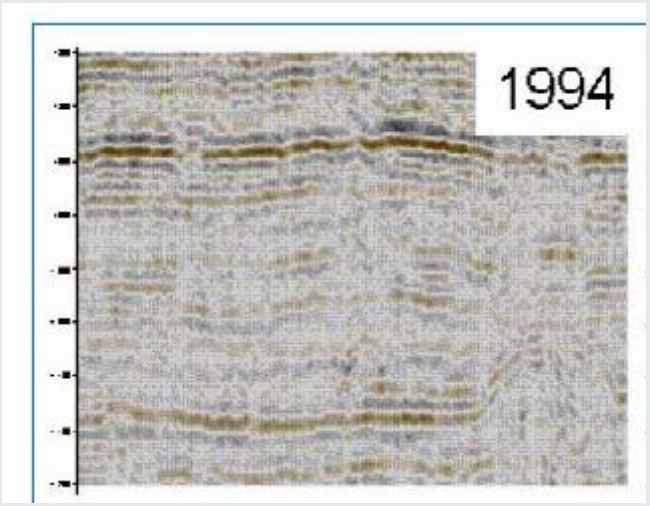
All these processes are time dependant. That is the proportion of the carbon dioxide trapped and thus the security of trapping increases over time and the length of the migration path

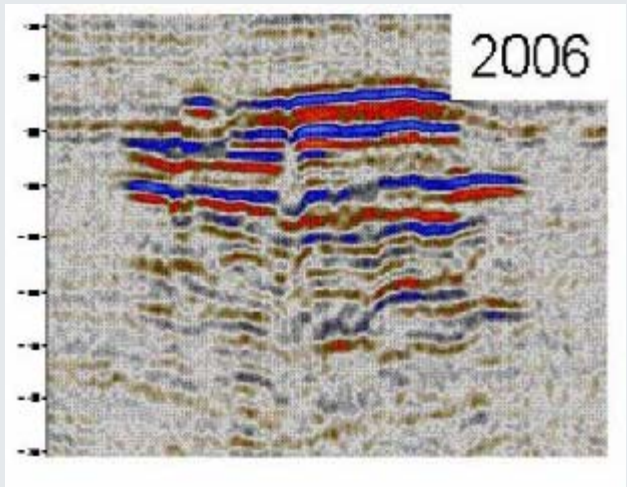
Saline Reservoir Trapping

Storage in saline reservoirs will also take place in sub-seismic structural and stratigraphic closures both at the base of the seal and with the body of the reservoir.

Trapping may occur under thin intrabed shales like these which are below seismic resolution before they trap the CO_2.

The Utsira Sandstone at Sleipner

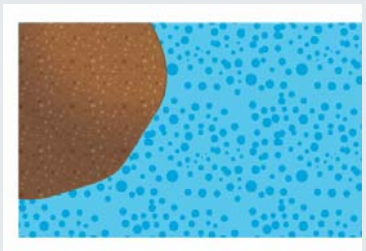




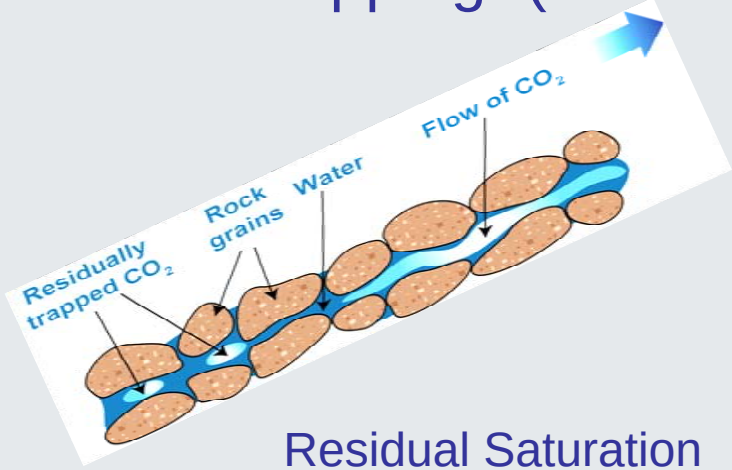
Interbeds revealed by CO_2 injection

Saline Reservoir Trapping – alternative terms

- Migration Assisted Storage- (CGSS 2009)
- Migration Associated Trapping- (CO2CRC 2010)

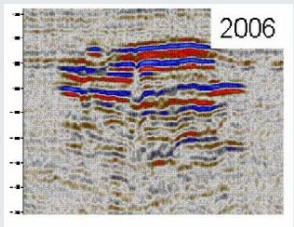


Dissolution



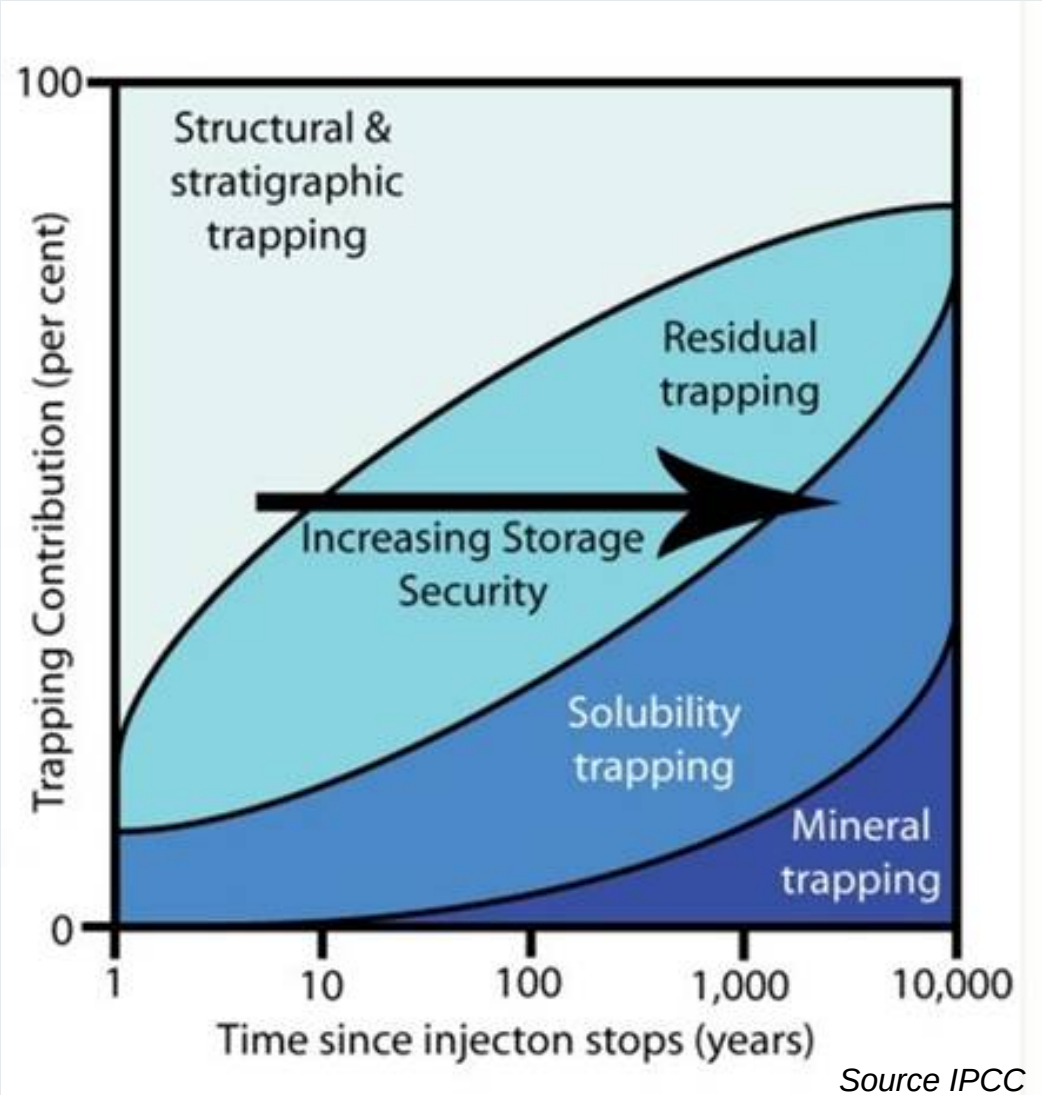
Residual Saturation

Mineralisation



Sub-seismic traps

Trapping security over time

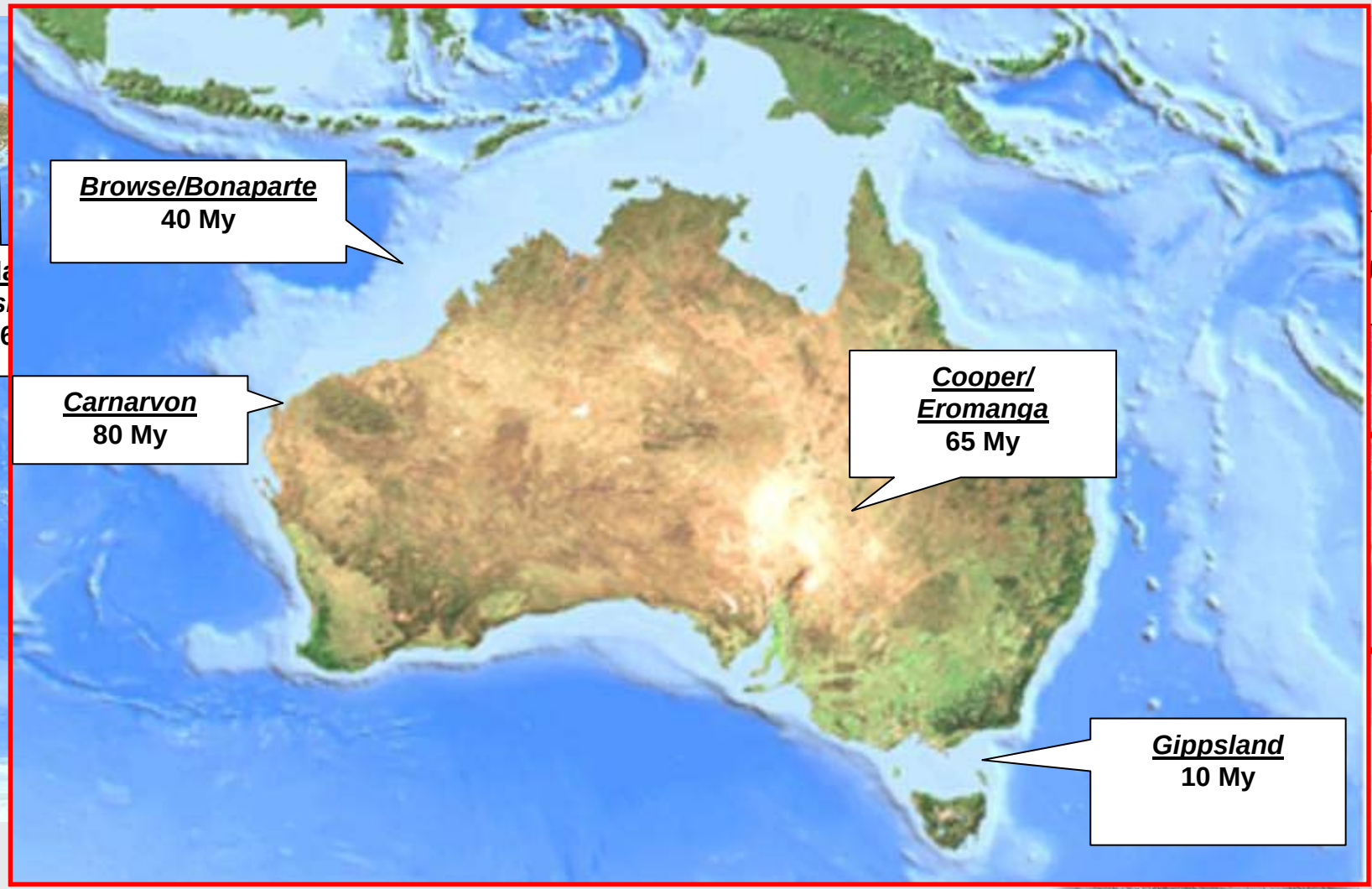


Source IPCC

How long will it stay there

- Naturally occurring fluids have been trapped underground for many millions of years
- Oil, natural gas and CO_2
- This can be shown by the study of petroleum systems.

Time Of Petroleum Charge Into Traps



Is This New Or Unproven Technology?

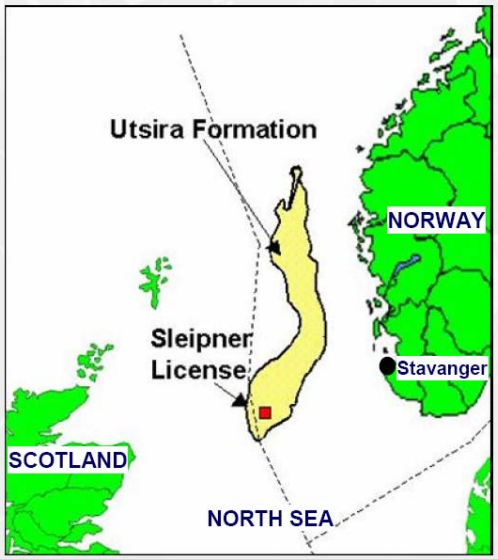
- The critical components of the CCS process are currently in use within the Oil & Gas Industry.
- Capture: Natural gas processing, ammonia plants other industrial processes.
- Transport: 5650 km of CO_2 pipeline in the USA.
- Injection: EOR – 70 projects in West Texas. Acid gas disposal
- Storage: Subsurface storage of natural gas for 100yrs. Deliberate storage of CO_2 since mid 1990s
- CO_2 storage in the North Sea since 1996

Source IPCC

Source IPCC

Geography of Sleipner

STATOIL

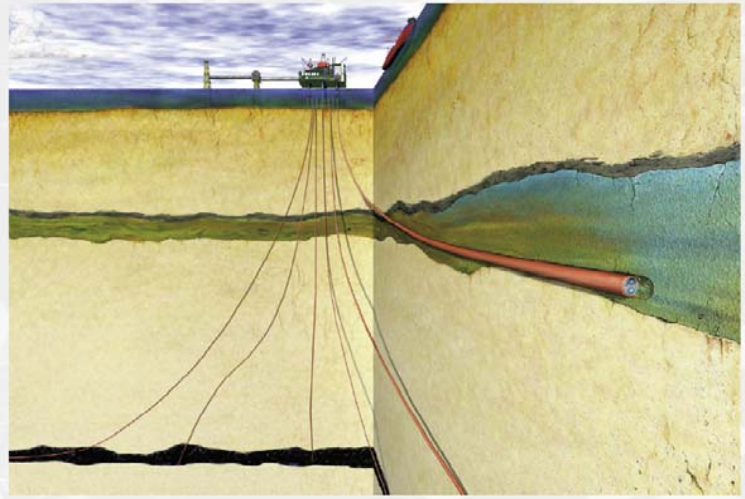


3

The Sleipner CO2-injection into the Utsira Formation at 1000 Meters Below Sea Bottom

- About 1 million tons/yr - Since 1996

STATOIL



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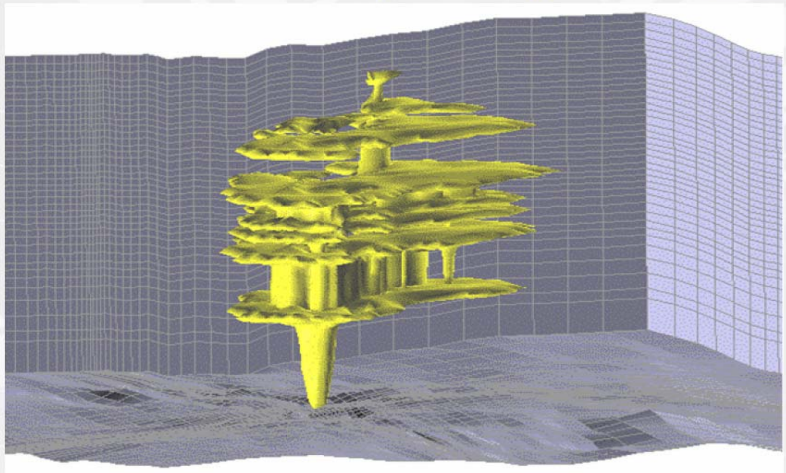
Reservoir model of CO_2 after 3 years

STATOIL



Source: SACS, Best Practise manual 2003

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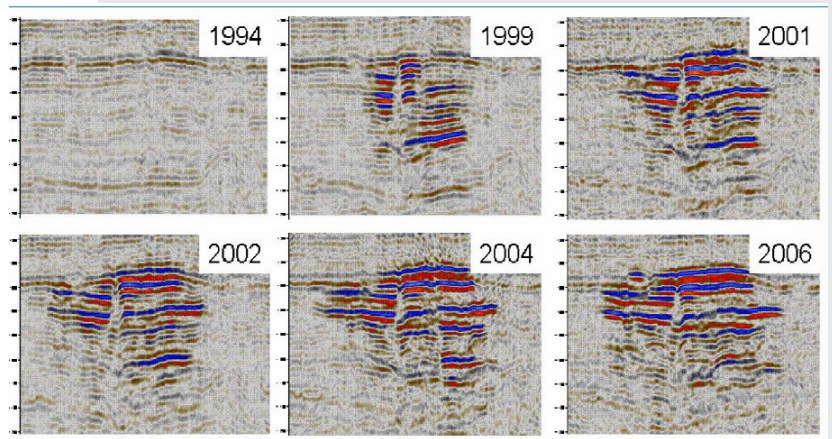

In conclusion:

- CCS is not the silver bullet to fix all our problems. It is part of a solution, together with developing renewable and efficient energy options.
- Petroleum studies show that oil, gas and CO_2 can be stored in the deep subsurface for geological time (millions of years).
- CO_2 is injected as a fluid into tiny spaces between grains in reservoirs (sandstones) and is trapped by seals (mudstones).
- The technology for the geological storage of CO_2 is mature and geological storage of CO_2 is already happening.

Questions?