Carbon Capture And Geological Storage
An Overview

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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

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

Large Scale CO_2 Emission Sources

- CO2 can be captured from a variety of sources
- Power Generation
- Gas Processing
- Cement Manufacturing
- Iron and Steel Production
- Fertiliser manufacture
- Hydrogen Production
- Chemical Refining

Three CO_2 capture routes in power

Post-combustion CO_2 capture	• Fossil fuel or biomass is burnt normally and CO_2 is separated from the exhaust gas
Pre-combustion CO_2 capture	• Fossil fuel or biomass is converted to a mixture of hydrogen and CO_2, from which the CO_2 is separated and hydrogen used for fuel
Oxy-combustion CO_2 capture	• Oxygen is separated from air, and fossil fuels or biomass are then burnt in an atmosphere of oxygen producing only CO_2 and water

At the present time, none of the options is superior; each has particular characteristics making it suitable in different power generation applications

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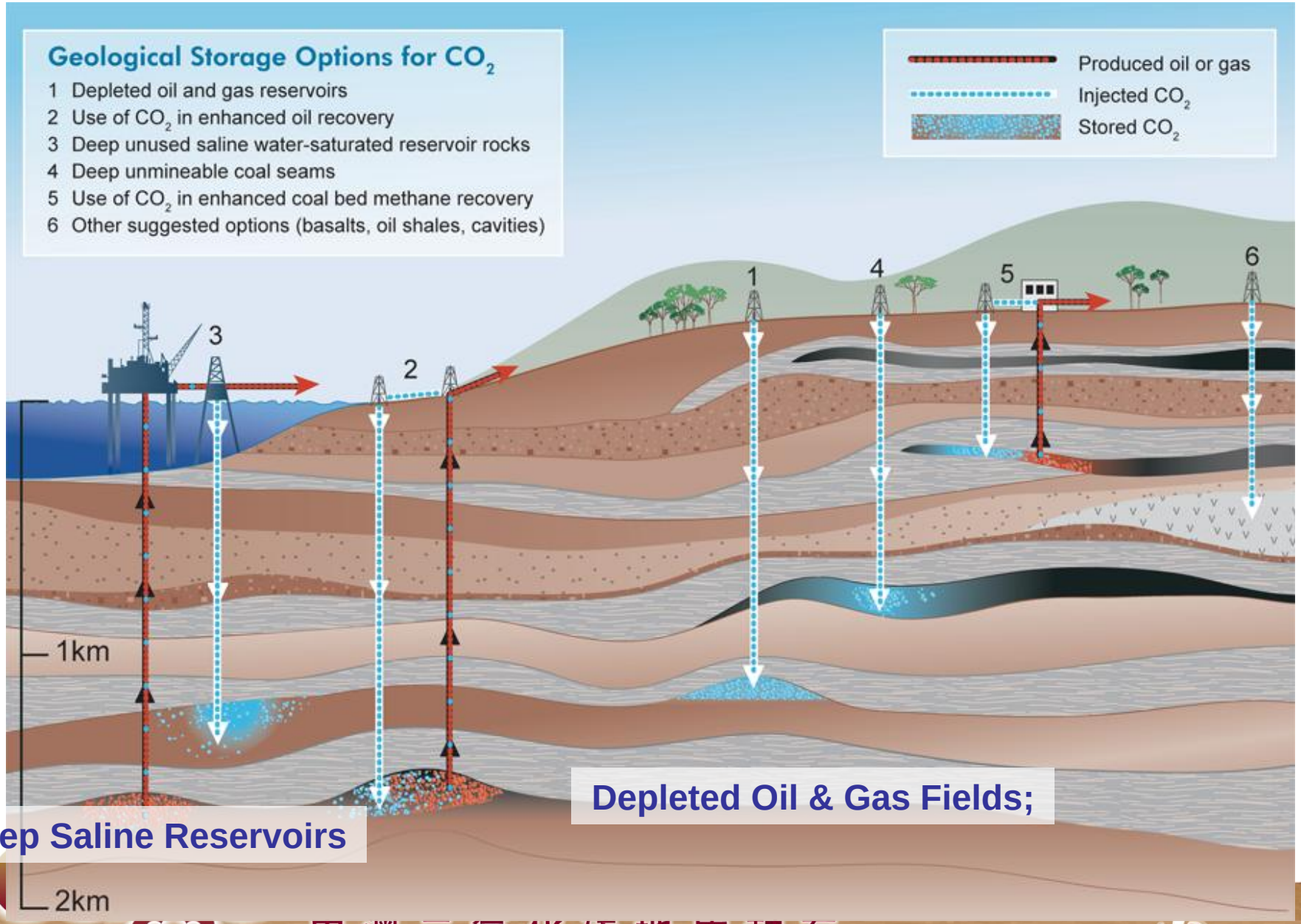
CO_2 Transport Options

Pipeline: Good experience with pipeline transport in the USA. In 2010 US had 6,600 km of pipeline that moved over 60Mt of CO_2

Ship: Transport of CO2 by ship has been demonstrated at a small scale, however similar to LNG transport will require extensive infrastructure for loading and unloading

Road or rail: Small scale only – pilot and demonstration projects

Options for Geological Storage



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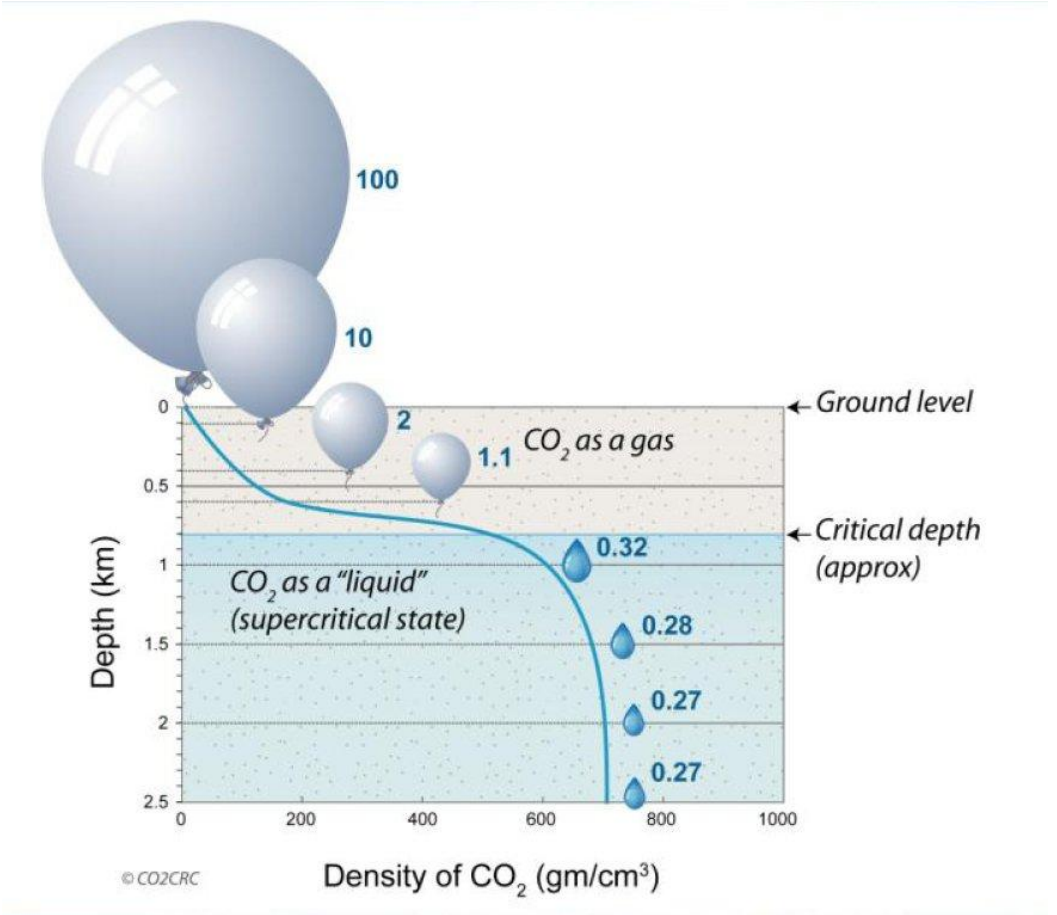
Source IPCC

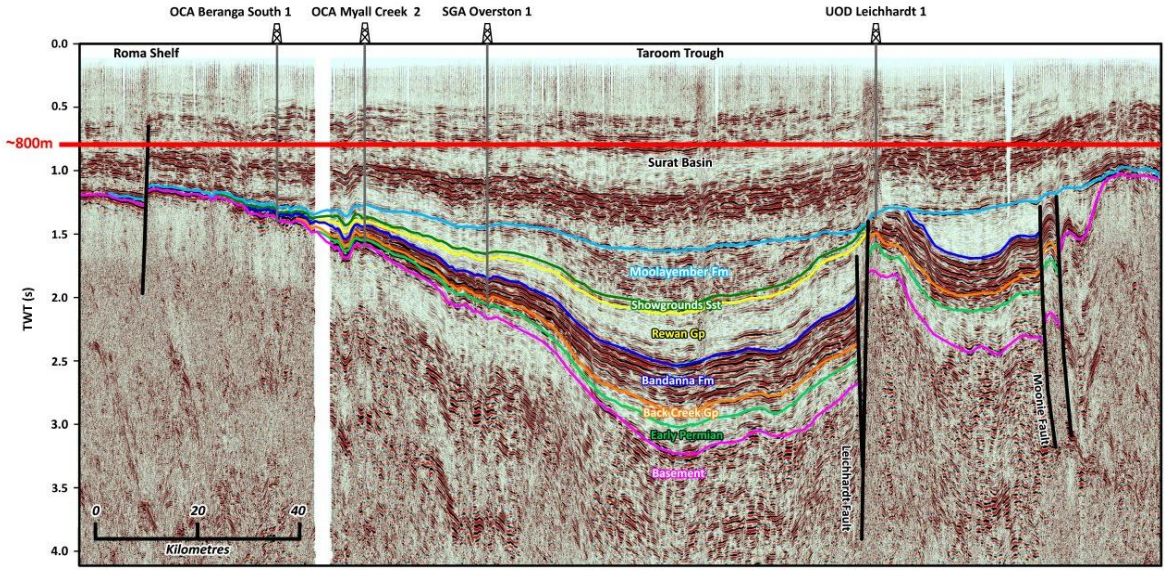
Why Supercritical CO_2

- 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



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.



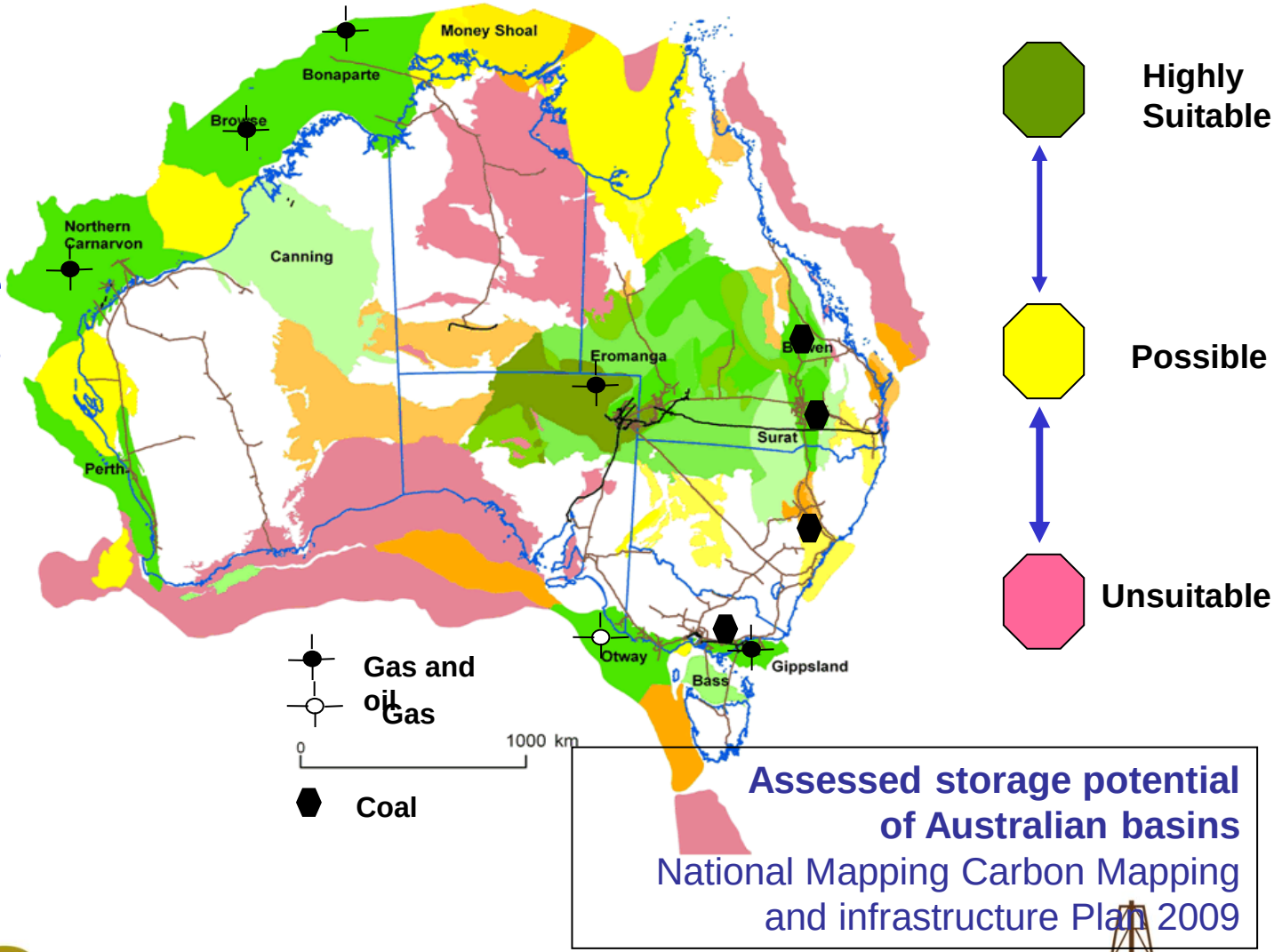
GSQ/GGSS Queensland Carbon Dioxide Geological Storage Atlas 2009.

All 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 when considering it for geological storage.

Not all sedimentary basins are equal

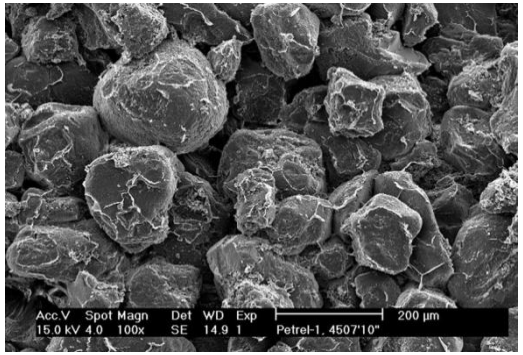
An example of the ranking of basins for carbon dioxide storage from a recent Australian Government Study conducted by Geoscience Australia

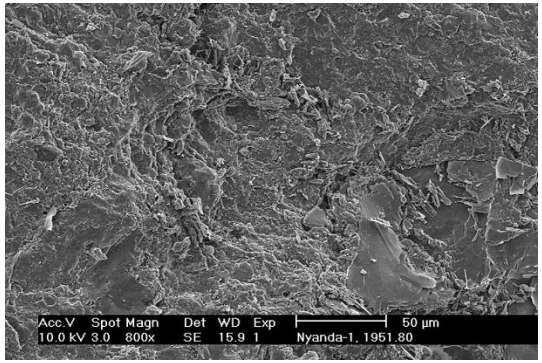


Assessed storage potential of Australian basins
National Mapping Carbon Mapping and infrastructure Plan 2009

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). Sandstones and limestones
- Sealing rocks are very fine grained with not practical permeability. Mudstones or shales.

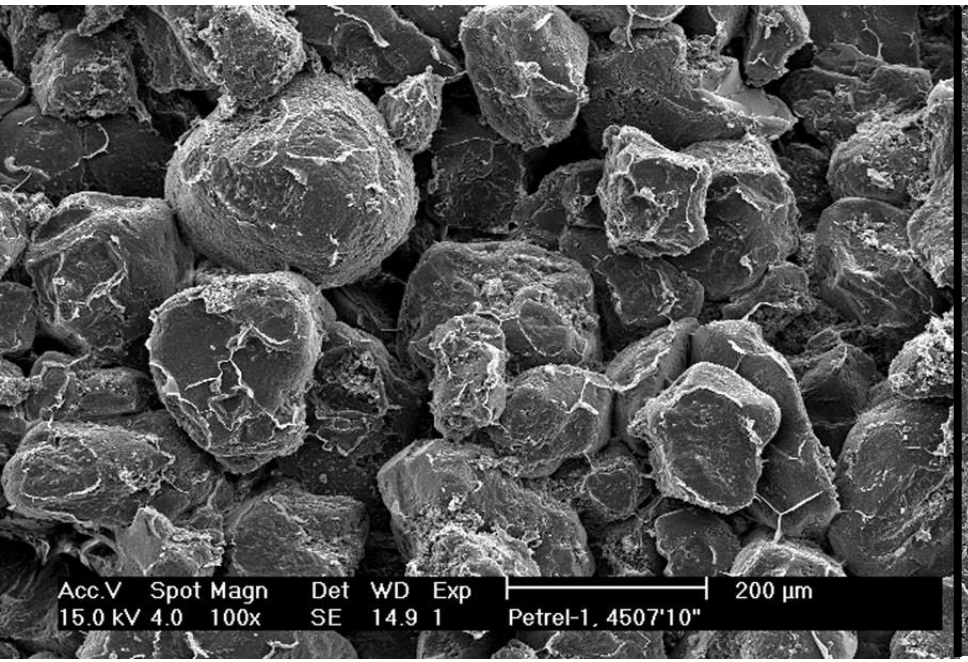


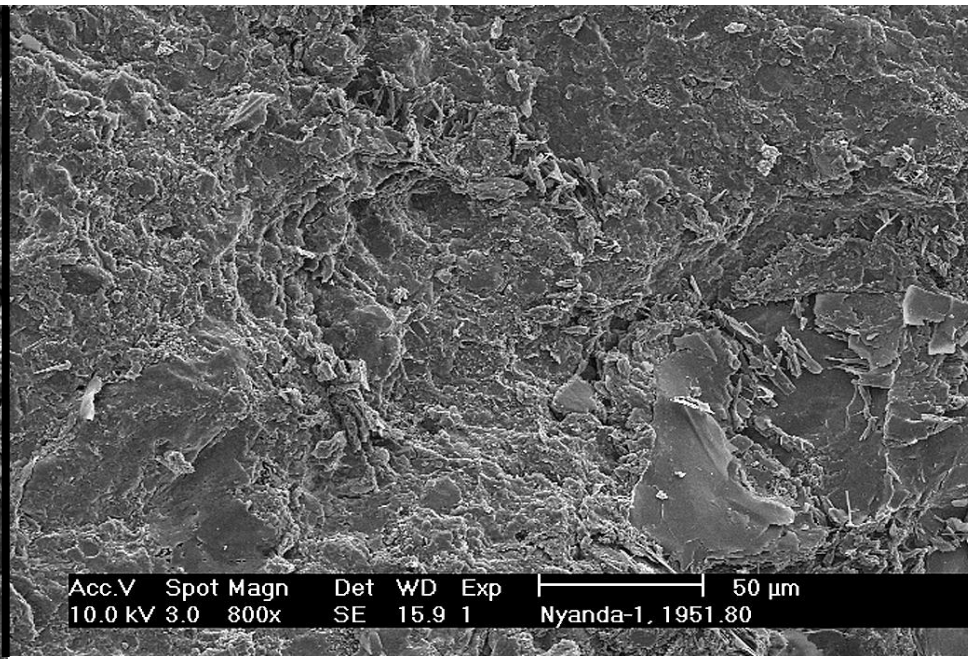


Reservoir v Seal

(Container)

(Lid)





~1 millimetre

~¼ millimetre

cags

China Australia Geological Storage of CO_2

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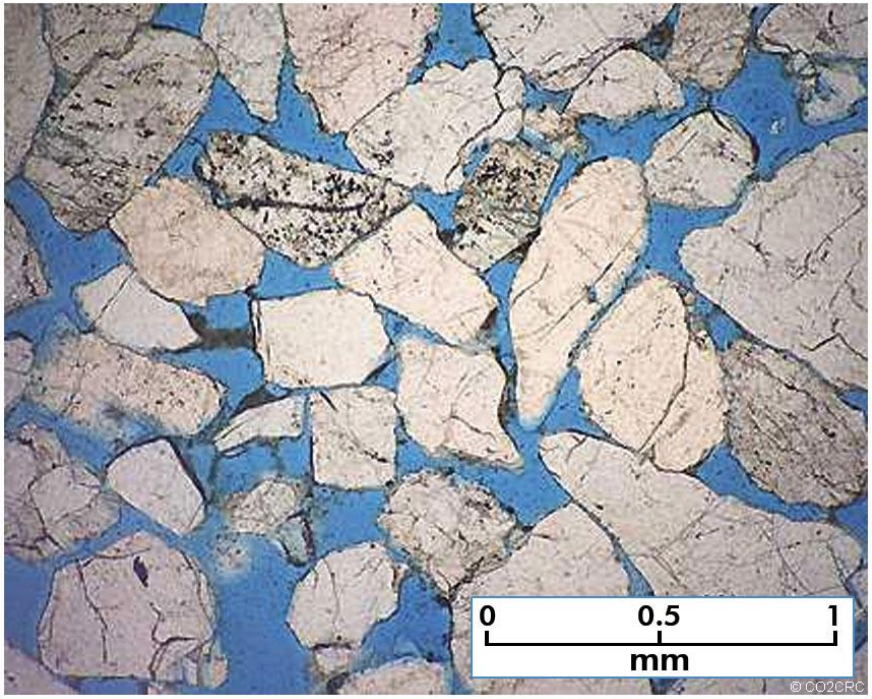
Reservoir Rock Properties

- A "very good" storage reservoir might have porosity approaching 30%; a marginal reservoir could be in the single digits.
- However even with good porosity, if the interconnections between the pores are blocked permeability will be low and injection difficult



Pore space is blue and grains of quartz are white in this photograph of a microscopic cross-section of rock (courtesy of CO2CRC)

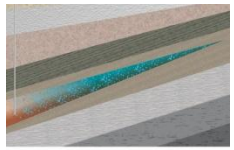
Reservoirs and Seals

In the sub-surface, 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.

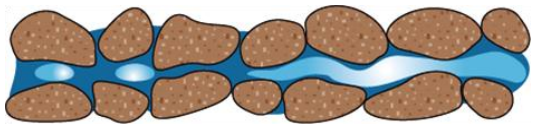
This relationship can be seen in this coastal outcrop

Trapping the carbon dioxide

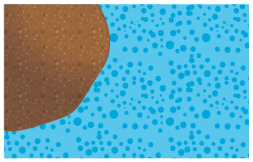
- Structural/stratigraphic trapping



- Residual trapping

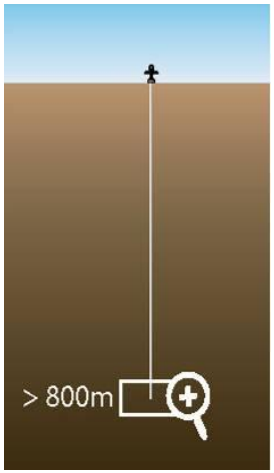


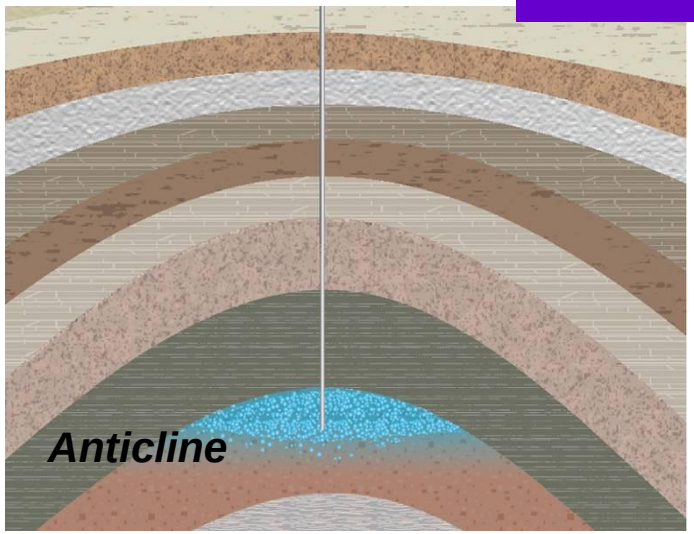
- Solubility trapping

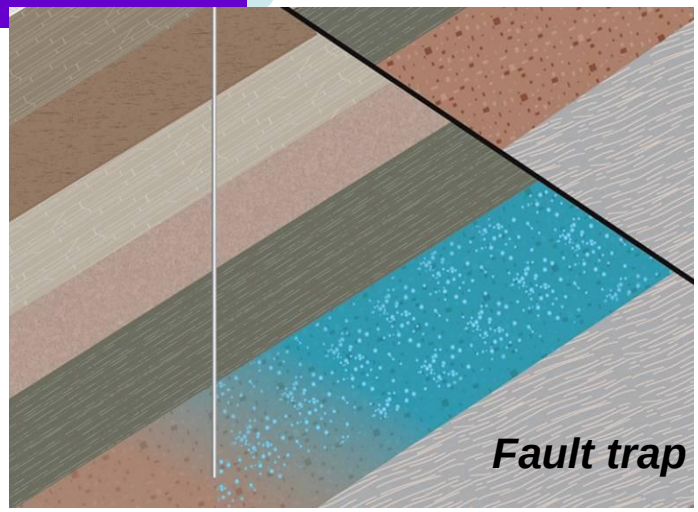


- Mineral trapping

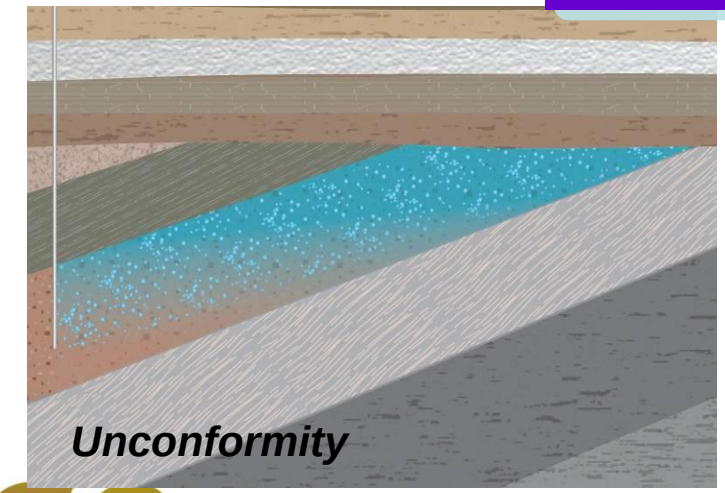
Structural trapping

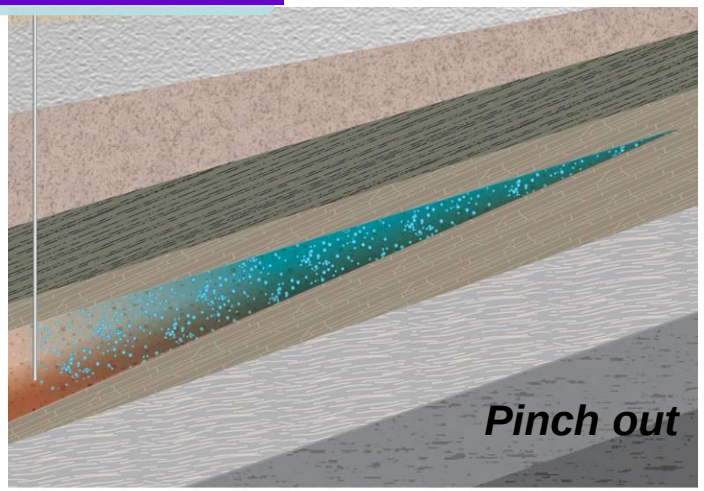




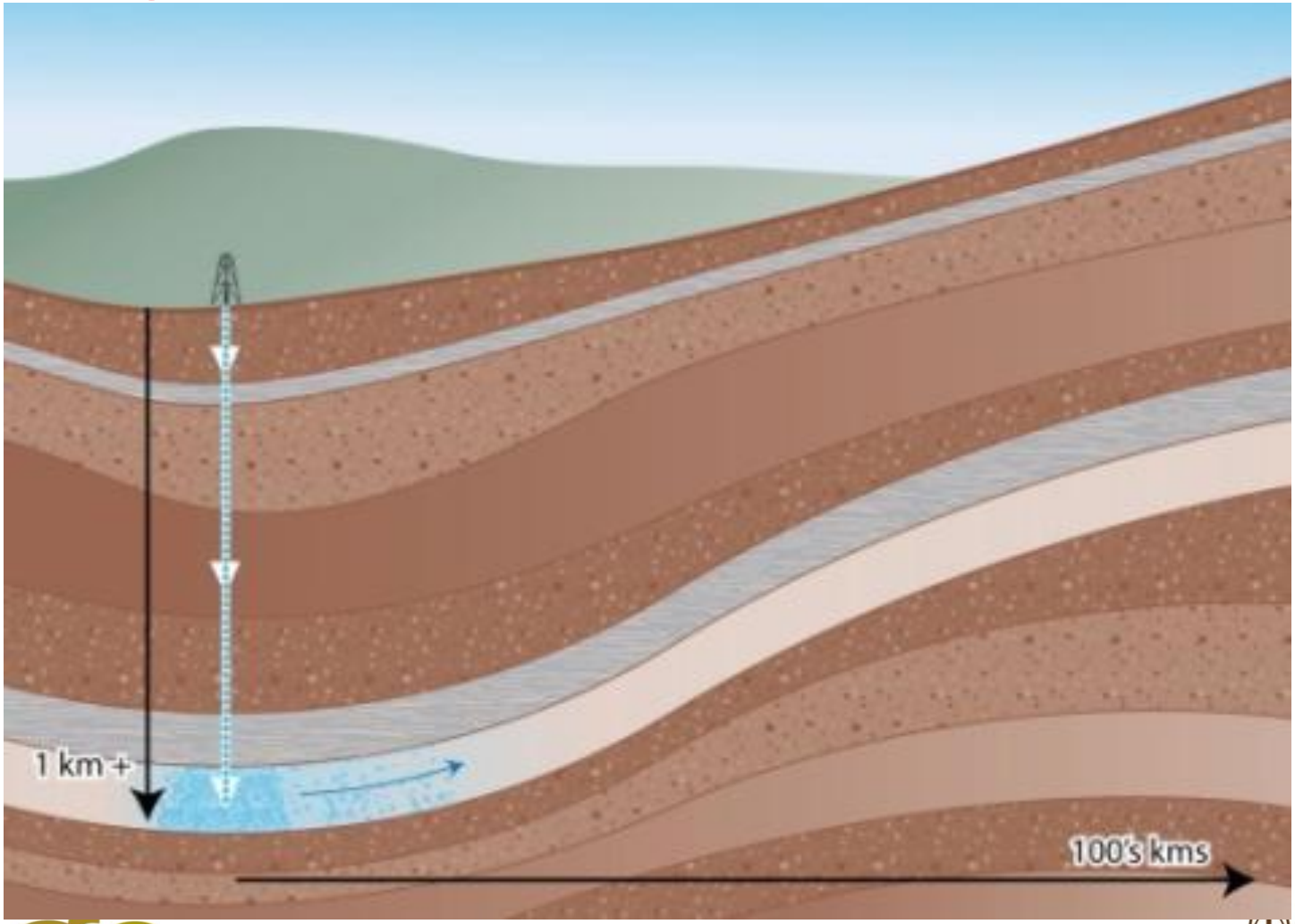


Stratigraphic trapping

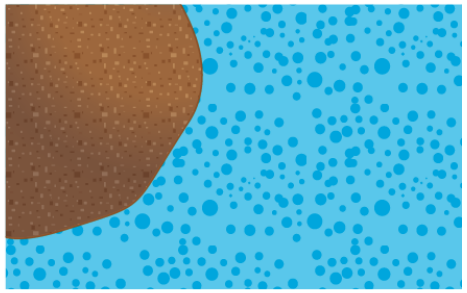




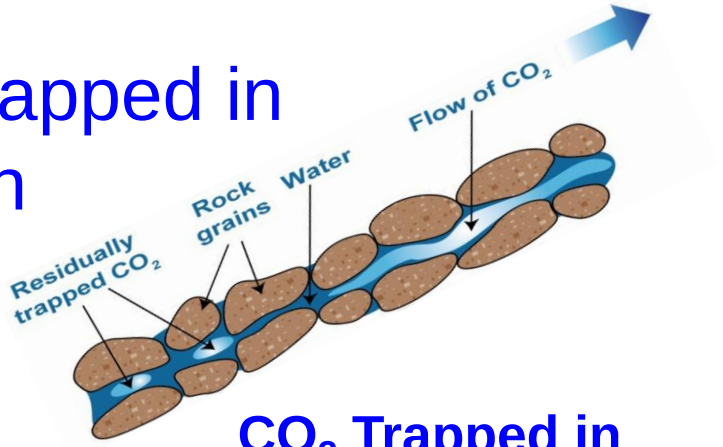
Storage in deep aquifers



Saline Reservoir Trapping



CO_2 Trapped in solution



CO_2 Trapped in rock pores as Residual Saturation (Sgr_{CO2})

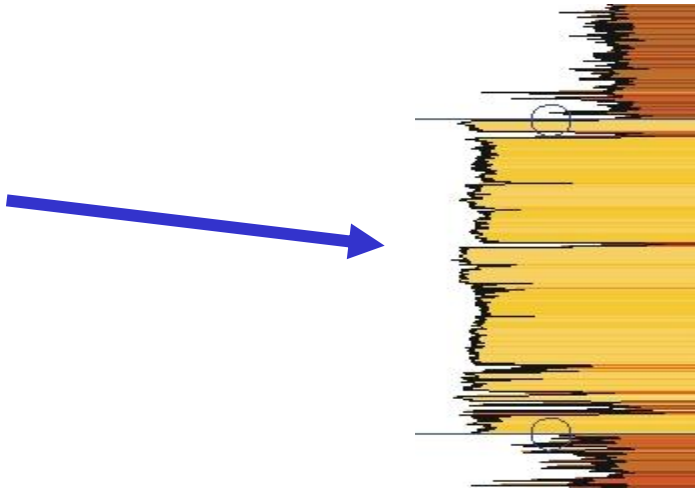
CO_2 Trapped as a mineral

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

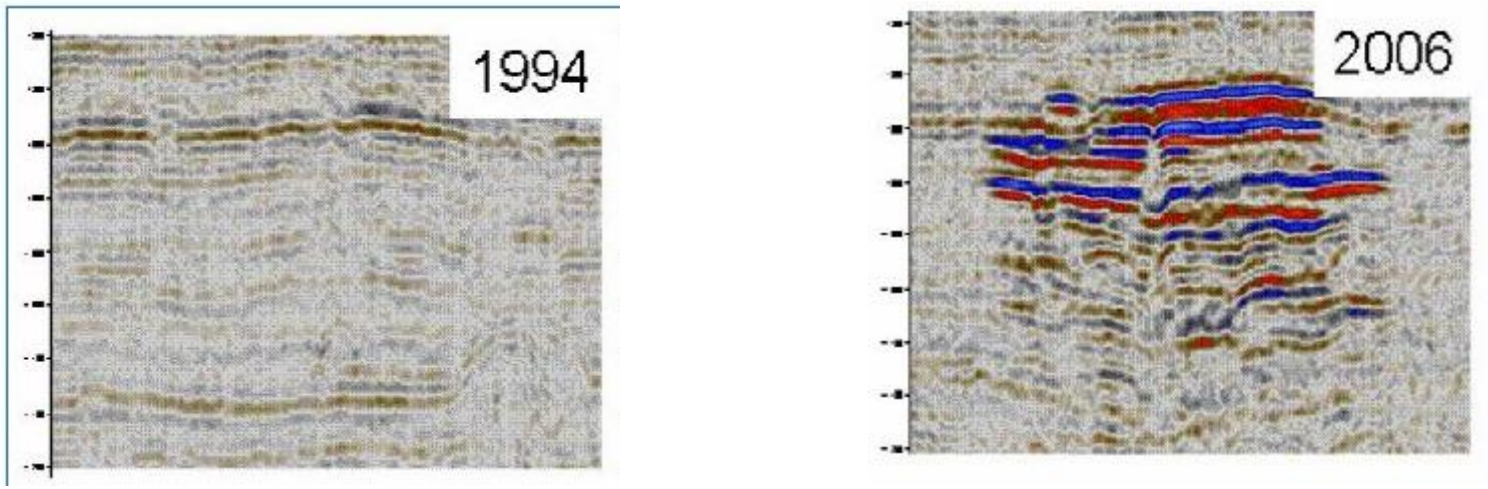
Saline Reservoir Trapping

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.



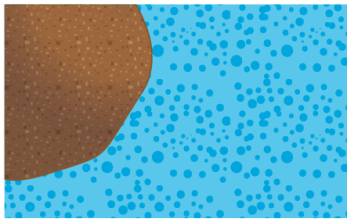
The Utsira Sandstone at Sleipner



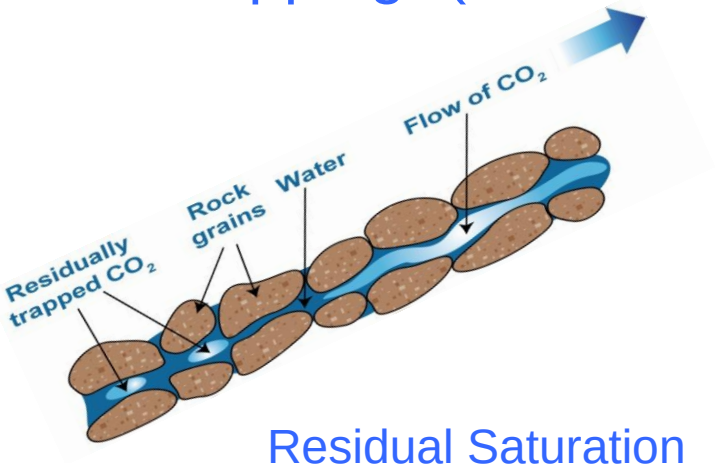
Interbeds revealed by CO2 injection

Saline Reservoir Trapping – Alternative terms

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

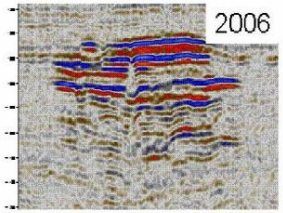


Dissolution



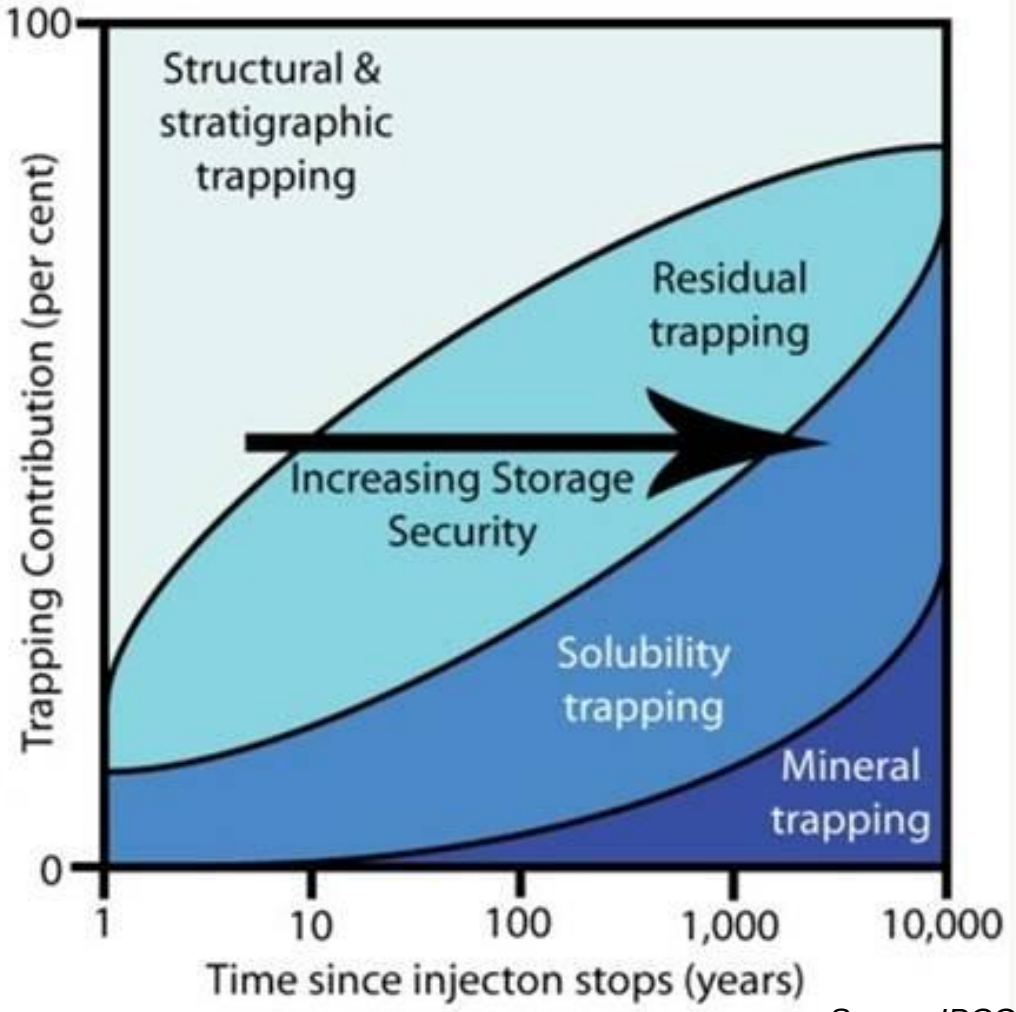
Residual Saturation

Mineralisation



Sub-seismic traps

Trapping security over time



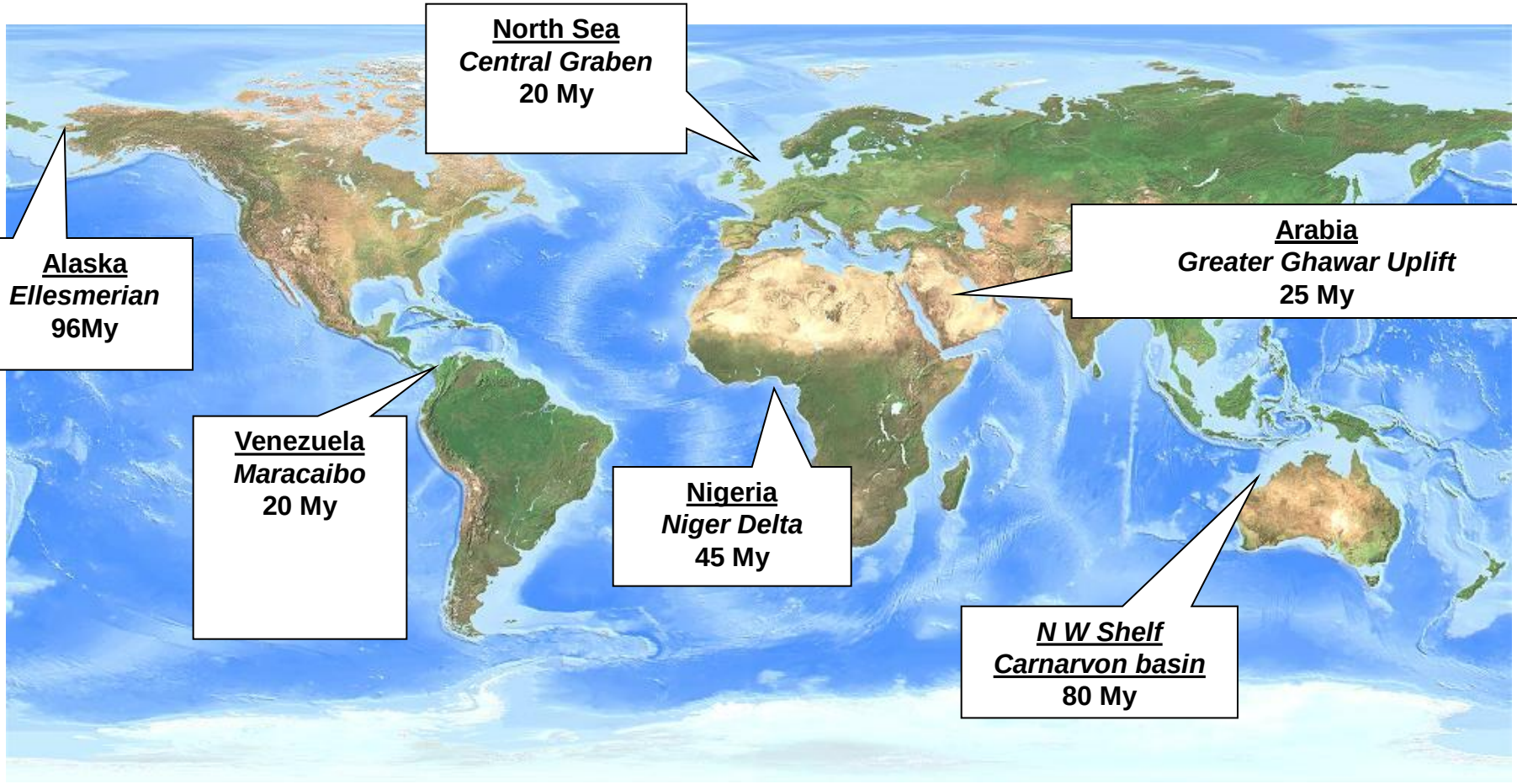
Source IPCC

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

Examples of deep saline aquifer storage projects

- Sleipner- Statoil has been injecting CO_2 into an aquifer in the north sea since 1996
  - Greater than 12 Mt CO_2

- In Salah- BP, Sonatrach, and Statoil injected CO_2 into the water leg of a gas bearing formation in Algeria between 2004 and 2012
  - Approximately 1.2 Mt CO_2 per year

The Gorgon Project -West Australia

- $43 billion LNG project
- Single biggest project in Australia
- World's biggest CCS program

- Greater Gorgon Fields lie 130-200km offshore and contain about 40 trillion cubic feet of gas
- Average 14% CO_2 in gas fields
- Processing Facility onshore Barrow Island 3x5Mtpa trains.
- CO2 storage below island
- Start up 2014

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.