Carbon Capture And Geological Storage
An Overview

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CHINA-AUSTRALIA GEOLOGICAL STORAGE

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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**

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Public Acceptance

The major obstacle to the uptake of CCS is the community's lack of understanding of the technology.

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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

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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**

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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

1) **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**

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**

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

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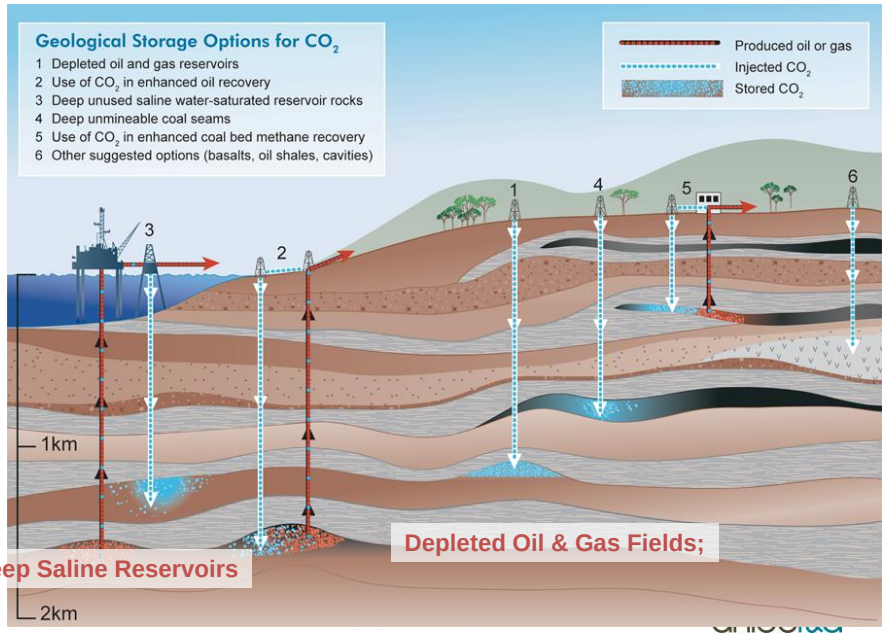
Options for Geological Storage



Source IPCC

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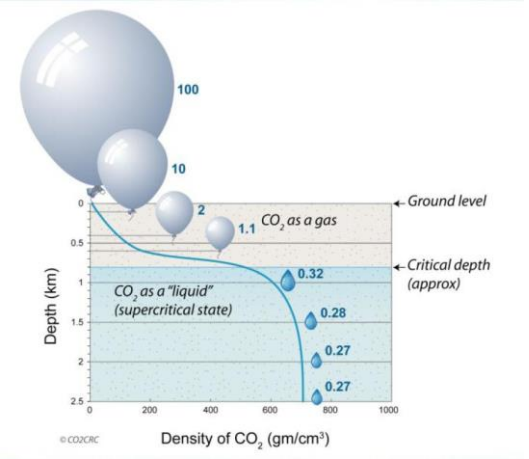
Why Supercritical CO_2

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



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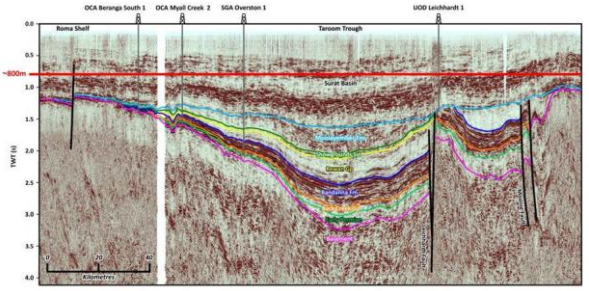
Sedimentary basins and geological storage

- **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.

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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.

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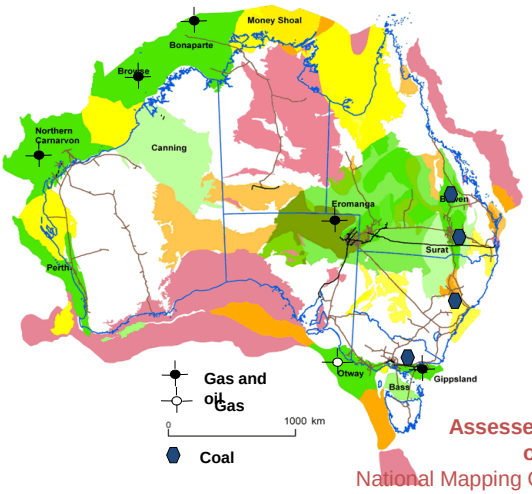
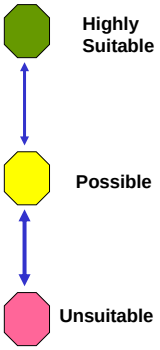
Not all sedimentary basins are equal

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

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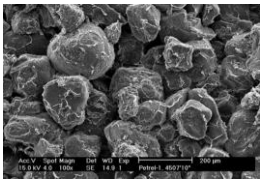
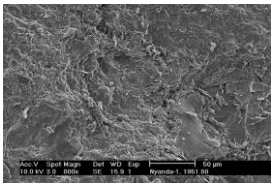
Reservoirs and Seals

- 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.





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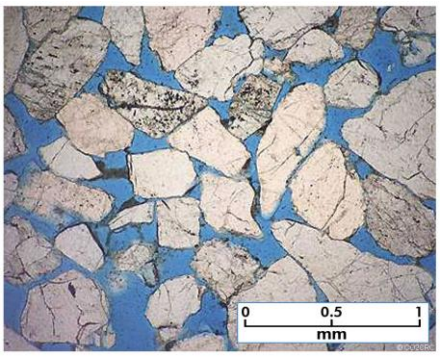
Reservoir Rock Properties

- **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)

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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

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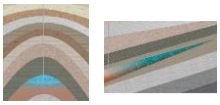
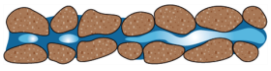
Trapping the carbon dioxide

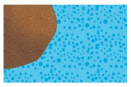
- **Structural/stratigraphic trapping**



- **Residual trapping**



- **Solubility trapping**



- **Mineral trapping**

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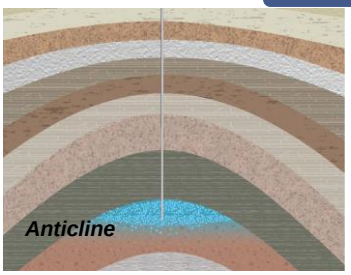
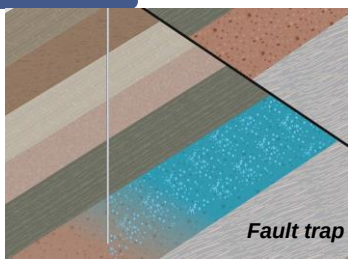
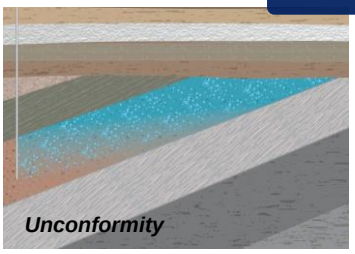
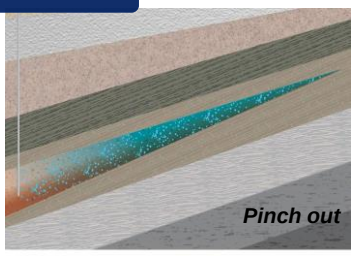
Structural trapping





Stratigraphic trapping





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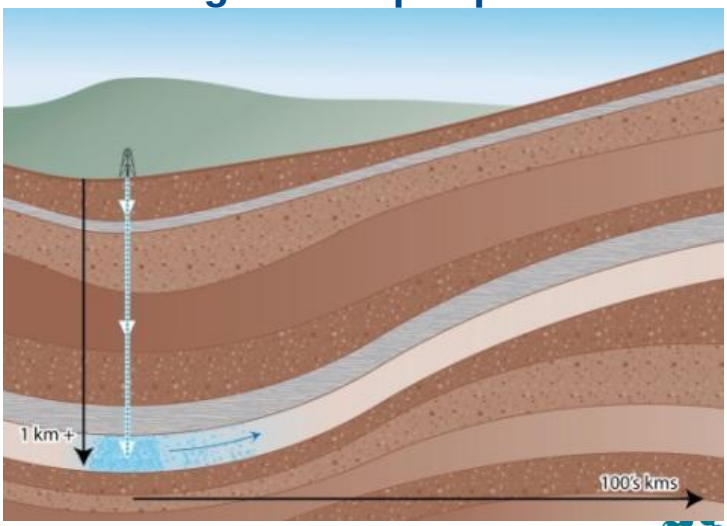
Storage in Deep Aquifers



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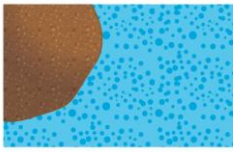
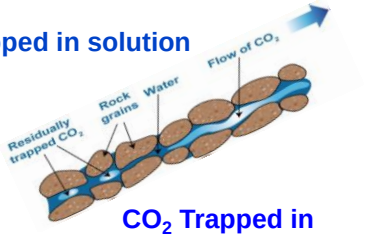
Saline Reservoir Trapping



CO_2 Trapped in solution



CO_2 Trapped as a mineral

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

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

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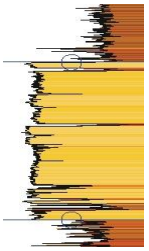
Saline Reservoir Trapping

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.



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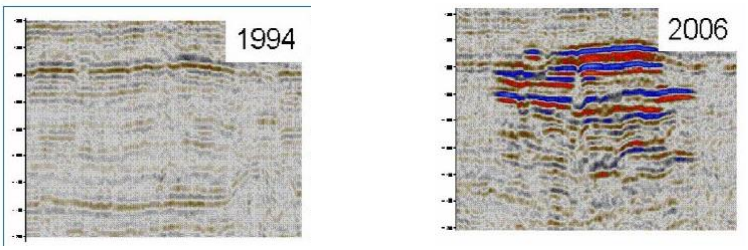
The Utsira Sandstone at Sleipner



Interbeds revealed by CO2 injection

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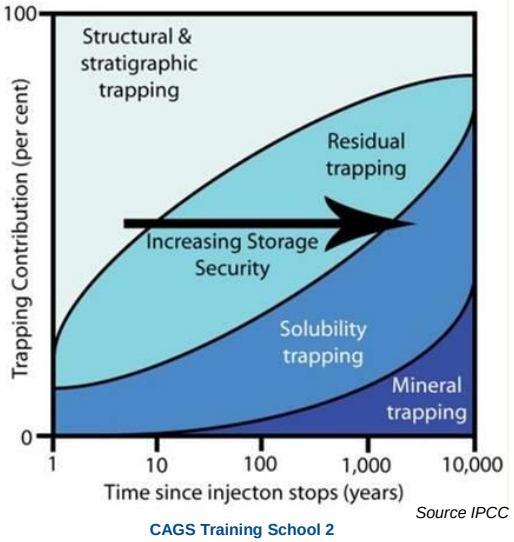
Trapping security over time



Source IPCC

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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.**

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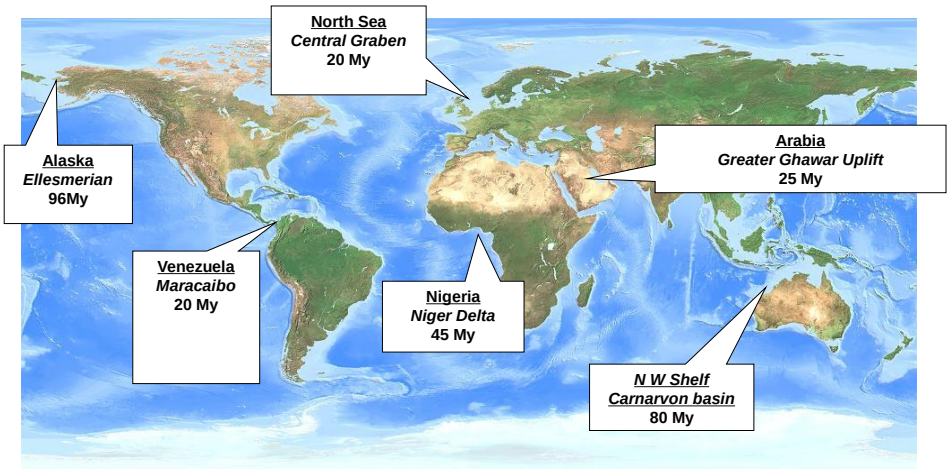
Timing Of Petroleum Charge Into Traps



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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

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Examples of deep saline aquifer storage projects

- Sleipner- Statoil has been injecting CO_2 into an aquifer in the North Sea since 1996
  - More than 17 Mt CO_2
- Snovit – Statoil has been reinjecting CO_2 into a saline aquifer in the Barents Seasince 2008.
  - Approximately 1.9Mt injected
- 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

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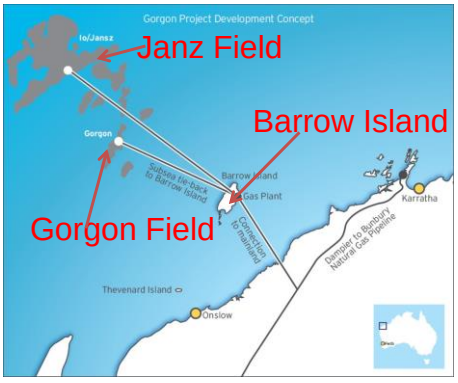
Boundary Dam – Saskatchewan, Canada
First Commercial CCS from a Coal fired Power station

Saskpower Boundary Dam 3 Unit has been rebuilt with an integral carbon capture facilty which will capture up to 1 million tonnes CO2/year.
The captured gas will be used for EOR in the nearby oil fields and the excess will be injected in a saline aquifer as part of the Aquistore Project

Start-up previously expected in April 2014 but this now put back due to delays in the power unit upgrade

The Gorgon Project
Largest CCS Project planned to commence in 2015



Project Operator:
Chevron Australia

Gas piped and separated on Barrow Island
CO_2 removed for sales gas
CO_2 compression attached to gas facility
Up to 3.4Mtpa of CO_2 will be captured, piped and stored in deep formations below Barrow Island

The Greater Gorgon Gas Fields lie 130-200km offshore and contain about 40 trillion cubic feet of gas
Water depths, Gorgon 270m Janz 1300m
CO2 content Gorgon 14%, Janz 0% , overall ~7%
Processing Facility onshore Barrow Island 3x5Mtpa trains.

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In Conclusion (1):

- **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.**

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In Conclusion (2)

The major barrier to the uptake of CCS is the community's lack of understanding of the technology.

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