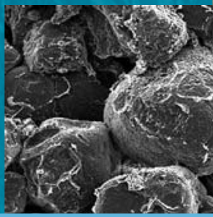
GEOSCIENCE AUSTRALIA



Geological storage of carbon dioxide

Frequently asked questions

Recently there has been considerable interest from the media and the public about geological storage of carbon dioxide. However this increase in public awareness has also shown that some concepts that geoscientists take for granted are not always fully understood.

So in an attempt to clarify the subject some frequently asked questions are explained below.

WHAT IS GEOLOGICAL STORAGE?

Geological storage is the process of capturing carbon dioxide from industrial processes such as power generation and injecting it deep underground for long term storage in geological formations, thus preventing it entering the atmosphere and adding to the potential for climate change caused by greenhouse gases. Among the options being considered for storage of carbon dioxide are injecting it into depleted oil and gas fields, deep saline reservoirs or deep unmineable coal deposits.

WHY DO WE NEED TO STORE CARBON DIOXIDE?

In the modern world we rely on electrical power to provide the quality of life that we enjoy and that the developing world is aiming to achieve. Most of the power used to meet our needs is derived from burning fossil fuels in power stations (figure 1). As renewable sources of energy are unlikely to be able to meet that demand, the dependence on fossil fuels as our major energy source is unlikely to change in the near future. The burning of fossil fuels releases carbon dioxide, which is the gas that has contributed most to the greenhouse gas effect. Capturing the carbon dioxide before it is emitted and storing it in the deep subsurface will help to reduce the impact of our use of energy. The development of this technology in Australia will not only reduce our emissions but also provide a lead to help the countries of the developing world reduce their greenhouse gas output.

HOW CAN YOU STORE ANYTHING IN SOLID ROCK?

Many sedimentary rocks, particularly sandstones, contain large volumes of fluids held in microscopic voids or pores between the rock grains. These pores can form up to 30 per cent of the rock volume (figure 2). Where the pores are interconnected the rock has permeability, that is, fluids can move through it. Rocks of this type form the underground reservoirs. Under normal conditions the pores in the rocks are filled with water, but under special conditions they may contain oil, natural gas (methane) or naturally occurring carbon dioxide. Many finer grained rocks such as clays also have high porosity, however the pores are not interconnected and fluids cannot move through them, that is, they are impermeable. These rocks act as seals or caps to the reservoir rocks over geological time, the weight of the overlying sediments gradually reduces the porosity of both sandstones and shales until they are effectively impermeable. Often, however, sandstones may still retain significant porosity and permeability at depths in excess of four kilometres.

Figure 1. Almost half of Australia's carbon dioxide emissions come from stationary sources and could potentially be stored. Three-quarters of these sequesterable emissions come from power stations.

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WHAT ARE 'DEEP SALINE RESERVOIRS'?

Under normal conditions the pore space in rocks close to the surface is filled with fresh or brackish water. Rocks which contain water that is fresh enough to be used for humans or stock are called aquifers. Where the rock is exposed at the surface it is able to be recharged by rainfall. This causes a flow of water through the aquifer. However, deeper in the geological section below the shallow aquifers, the pores are filled with highly saline waters that have only moved slowly, if at all, over millions of years. This length of time together with pressure of deep burial has resulted in these waters dissolving minerals from the rocks and reaching salinities sometimes many times that of seawater. Rock formations which contain these highly saline waters are called deep saline reservoirs. These highly saline waters do not rise to the surface and are only found during the search for oil and gas in the deep subsurface. They are too deep and too saline for any practical use and it is proposed to store the carbon dioxide in these reservoirs.

HOW WILL THE CARBON DIOXIDE BE STORED IN THE ROCK?

Carbon dioxide behaves in the subsurface in the same way as naturally occurring oil and gas. Oil and gas are more buoyant than water, and when they are generated in the subsurface by the action of the earth's heat, they enter the water filled pores of the rock and rise until they encounter a permeability barrier such as a shale bed. If the shape of the barrier is such that they cannot escape sideways, the fluids will remain trapped there as hydrocarbon accumulations for millions of years. It is these traps that oil companies explore for. In geological storage, carbon dioxide will be injected into the rock as a supercritical fluid, which means it is as dense as a fluid but behaves in many ways like a gas. This carbon dioxide will act like the naturally occurring gases and gradually rise from where it is injected until it reaches a barrier that will stop it from rising further. Careful selection of the injection site will ensure that such a barrier exists in the path of the rising carbon dioxide. Over time, much of the carbon dioxide will dissolve into the deep saline waters and be held permanently in solution. Some will react with minerals in the rock and be precipitated out as new minerals leaving only a small amount to remain trapped as a supercritical fluid.

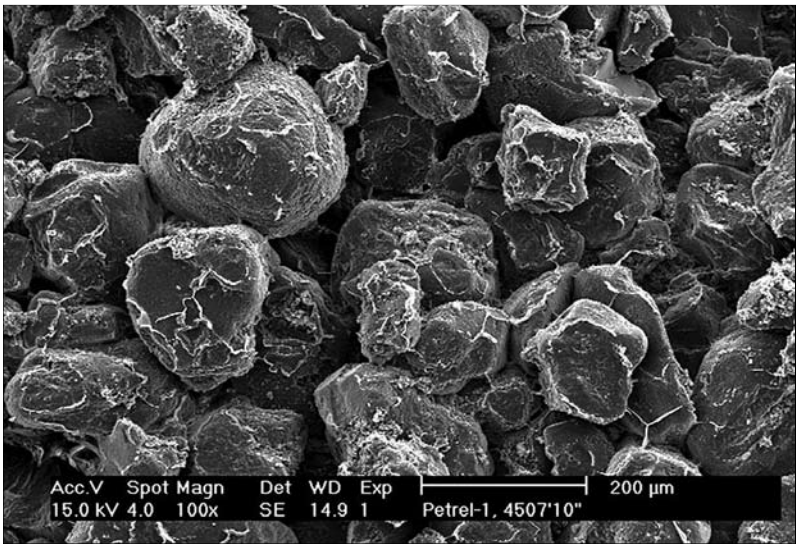


Figure 2. Under high magnification the pores between the grains in this sandstone can be seen.

COULD THE CARBON DIOXIDE CONTAMINATE THE FRESH WATER SUPPLY?

The selection of the injection site is one of the most important issues in the underground storage of carbon dioxide. Because the aim of the process is long term storage, any injection site where there is not an adequate barrier between the deep reservoir and the shallow aquifer would be unsuitable for geological storage. From studies of oil and gas fields, scientists have a clear idea of which seals or barriers work best in each area. Often these seals are the same ones that already seal subsurface oil and gas accumulations. The identification of suitable storage sites is a critical part of the research that Geoscience Australia is currently undertaking.

HOW LONG WILL IT BE TRAPPED THERE?

The petroleum industry is over a hundred years old and during this time geologists and other scientists have been studying the conditions under which oil and gas are generated and trapped in the subsurface. The importance of oil to the world economy since the middle of the twentieth century has meant considerable resources have been directed at understanding the environment in which hydrocarbon accumulations occur and how they are preserved. Research in hydrocarbon bearing basins worldwide has shown that it is possible to determine the time that the source rocks started to generate oil and gas, and show how long these fluids have been held securely in the adjacent traps. In almost all cases this is tens to hundreds of million years. The fact that the sealing rocks have held naturally generated oil and gas accumulations over such a period, often with naturally occurring carbon dioxide, demonstrates that they can contain carbon dioxide that is purposefully injected into them for similar lengths of time.

WHERE ARE THE BEST SITES FOR LONG TERM CARBON DIOXIDE STORAGE?

Previous research carried out by Geoscience Australia has demonstrated that sedimentary basins, particularly those that are hydrocarbon producing, are the best geological provinces for the storage of carbon dioxide. This is because the conditions that allow for the trapping of oil and gas are also those required for the storage of carbon dioxide. These basins are also the ones we have the most information about because it was gathered whilst exploring for hydrocarbon resources. However some basins that lack suitable source rocks for oil and gas could also make excellent storage sites, although less is known about them since they are less explored. Gas fields from which almost all the gas has been extracted (depleted fields), are the prime candidates for early storage opportunities. This is because they have already demonstrated they can trap and retain large volumes of gas. In the USA, fields of this type which are close to populated centres are often used to store natural gas produced from more remote locations. In addition, some other structures that have never contained oil or gas could also provide suitable sites but further research is needed to demonstrate their potential.

COULD A HYDROCARBON SEAL LEAK?

Under normal conditions the seal of a hydrocarbon trap may start to leak, and allow small quantities of gas to pass through and continue to move upwards through the rock column until it is trapped against barriers, or sometimes to be released at the surface as 'seeps'. This process reduces the pressure on the seal which then 'closes' again. In the natural world this process is uncontrolled. However in a carbon dioxide injection project the capacity of the rock seals will have been measured in the laboratory and their limits known. In addition the injection wells and the storage site will be monitored by remote sensing devices that will enable the process to be slowed or halted if the pressure builds up faster than anticipated. This will allow excess pressure to be dissipated and when conditions are right, injection can re-commence. This knowledge of the way the natural system works will enable the injection of the carbon dioxide to be controlled in such a way that it will not threaten the seal.

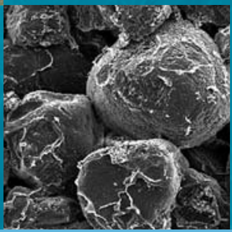
Figure 3. The Sleipner Project in the Norwegian North Sea has injected one million tonnes of carbon dioxide into a sandstone 900 metres below the seabed every year since 1996 (Courtesy of Statoil).

If the seal is not perfect, there could be some potential for some gas to slowly leak out over time, and start to travel upwards through the overlying rock. However the complexity of the normal geological column is such that any escape pathway would be tortuous and the fluid movement slow, so that the time taken for even small amounts to reach the surface would be of the order of thousands of years.

DO WE HAVE THE TECHNOLOGY TO INJECT CARBON DIOXIDE UNDERGROUND?

The basic technology used to inject carbon dioxide deep underground has been used in the petroleum industry for some time to 'enhance' oil or gas recovery from depleting oil reservoirs. Currently there are several international projects injecting carbon dioxide underground for either storage or enhanced oil recovery.

- In the Norwegian North Sea, in the first direct storage project, naturally occurring carbon dioxide is stripped out of natural gas produced from the Sleipner Field and reinjected into a deep saline formation 900 metres below the sea bed for storage (figure 3). Since this project started in 1996 over one million tons of carbon dioxide has been injected per year, and seismic techniques have monitored the successful dispersion and trapping of the gas within the formation.
- In a similar project in Algeria, which commenced in 2004, carbon dioxide is stripped from the natural gas produced at the In Salah Field and reinjected back into the gas reservoir for long term storage at the rate of one million tonnes per year.



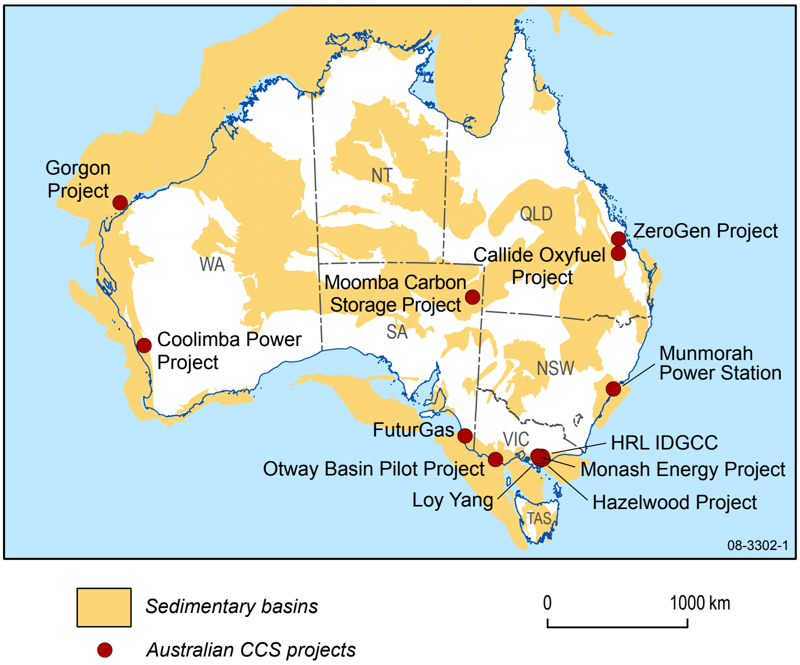
- In Saskatchewan, Canada, carbon dioxide is being used for enhanced oil recovery in the Weyburn Field.
- At the Snøhvit field in the Barents Sea, north of Norway, carbon dioxide from a LNG (liquefied natural gas) plant is captured and stored. Gas from Snøhvit is transported to the LNG facility on Melkøya Island via a 145 kilometre long pipeline, the carbon dioxide is separated at this site and then returned to the Snøhvit field along a second pipeline where it is reinjected and stored below the gas field.

These examples and a wide range of other carbon dioxide storage and enhanced oil and gas recovery projects from places as diverse as the USA, Turkey, Mexico and the Russian Federation demonstrate the maturity of carbon dioxide injection technology.

ARE THERE ANY GEOLOGICAL STORAGE PROJECTS IN AUSTRALIA?

In Australia there is currently one project that is storing carbon dioxide underground. In western Victoria, the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC) is injecting carbon dioxide into a depleted gas field in the Otway Basin.

Figure 4. *The location of carbon capture and geological storage projects in Australia.*



They aim to store 100,000 tonnes of carbon dioxide by 2010 and to monitor the migration of the gas within the subsurface.

Other projects which are in the advanced stages of planning include the Gorgon and ZeroGen projects (figure 4). Chevron, the operator of the Gorgon gas field, has a proposal for a carbon capture and geological storage project linked with the gas field development which would store the carbon dioxide deep beneath Barrow Island off the coast of Western Australia, while the ZeroGen project intends to capture carbon dioxide from a power plant near Rockhampton, with subsequent storage in western Queensland.

Geological storage of carbon dioxide is a leading edge, proven technology that is an important part of the challenge to allow the benefits of plentiful energy to be enjoyed by both developing and developed countries whilst not continuing to add to the greenhouse gas load in the atmosphere.
The work of Geoscience Australia in researching and identifying suitable sites for geological storage of carbon dioxide will ensure Australia continues to be a leader in the development of this technology.

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