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The search for new oil and CO_2 storage resources: Residual oil zones in Australia

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Residual Oil Zones (ROZ) could present a new, commercially viable oil and CO_2 geological storage resource for Australia that can be accessed through CO_2 enhanced oil recovery (CO_2-EOR).

These reservoirs contain a small to moderate amount of residual oil and resemble water-flooded oil fields. They can be associated with conventional fields, or occur with no associated main pay zone.

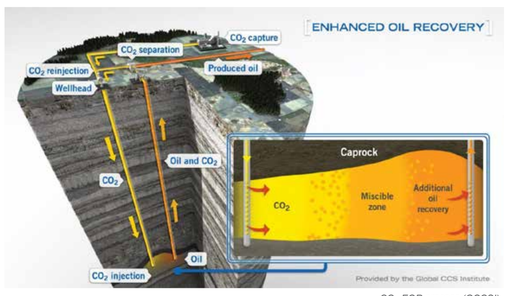
Both types of ROZ are currently produced commercially through CO_2-EOR in the Permian Basin, USA, and are of growing interest internationally.

We aim to identify, characterise, quantify and predict the occurrence of ROZ in key Australian basins using geological, petrophysical, experimental and predictive methods.

Motivation

Chasing new oil and economic CO_2 storage

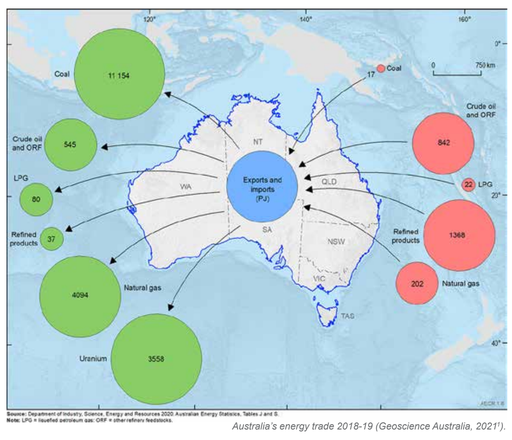
CO_2 enhanced oil recovery in depleted fields and residual oil zones…



CO_2-EOR process (GCCSI).

CO_2-EOR is a proven technology that has been routinely used since the 1970s to extend the life and maximise oil production from oil fields. In this process, CO_2 is injected into an oil-bearing reservoir where it mobilises some of the remaining oil and drives it to producing wells. CO_2-EOR is key to producing the residual oil that is found in residual oil zones.

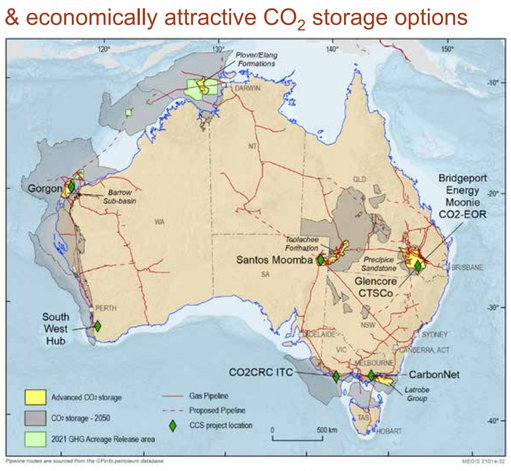
= increased domestic oil supply



Australia's energy trade 2018-19 (Geoscience Australia, 2021[1]).

Australia is increasingly relying on importing more oil and refined petroleum products, and producing oil fields are depleting at a rate that surpasses the development of new fields and resources.

& economically attractive CO_2 storage options



CCS projects in Australia (Geoscience Australia).

Carbon capture and storage (CCS) is one of the key technologies that can help achieve net zero CO_2 emissions by 2050. Several CCS projects are underway or in development around the country. CO_2-EOR could both enable and benefit from widespread deployment of CCS[2]. The addition of ROZ could expand our portfolio of CO_2 geological storage resources.

Finding ROZ

Petroleum systems and petrophysical analysis

What is the target?

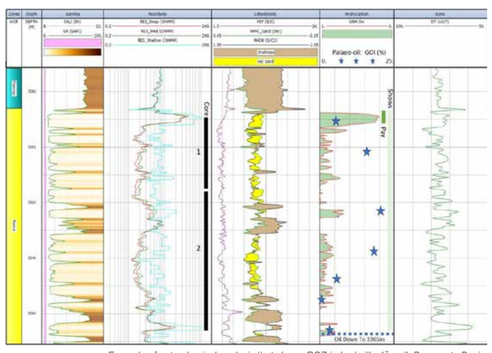
Residual oil zones are water-saturated reservoirs that contain some residual oil saturation, and can form due to:

- basin tilting that establishes a new oil-water contact;
- seal breach that has allowed natural leakage or oil and water invasion from underlying aquifers;
- displacement of oil due to tilting or hydrodynamic drive.

Examples of producing ROZ can be found in the Permian Basin, USA:

- The Seminole oil field has undergone primary through tertiary recovery of the main pay zone and is expected to produce an additional 225 mmbbl of oil from the ROZ[3].
- Tall Cotton, also in the Permian Basin, is producing more than 3,000 bopd from a greenfield (no main pay zone)[4,5,6].

Geological and petrophysical interpretation

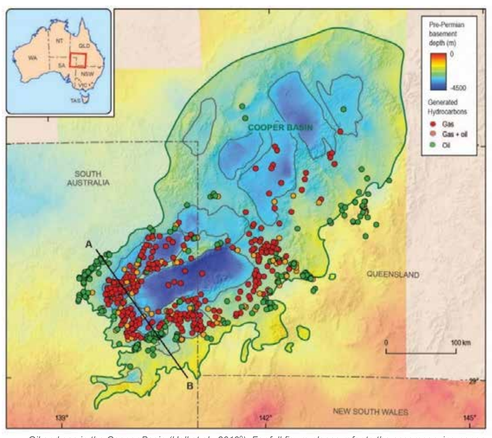


Example of petrophysical analysis that shows ROZ in Ludmilla-1[7] well, Bonaparte Basin.

Our workflow[8] aims to identify and characterise the oil saturation in potential residual oil zones. We have used knowledge of the area's petroleum system(s), geology, and data availability to identify candidates for detailed petrophysical analysis.

The petrophysical analysis is largely based on the resistivity signature of logs that have been collected over the years. In general, resistivity of residual oil zones will be higher than for a purely water-saturated rock, although analysis and interpretation becomes more complex when there is a significant clay component in the reservoir rock. The analysis is supported by other data such as the presence of oil shows.

Where are we looking?



Oil and gas in the Cooper Basin (Hall et al., 2019[9]). For full figure please refer to the accompanying paper.

Both mature hydrocarbon provinces and under-explored basins could host ROZ, such as the Cooper, Eromanga, Pedirka, Amadeus, Surat and Bonaparte basins.

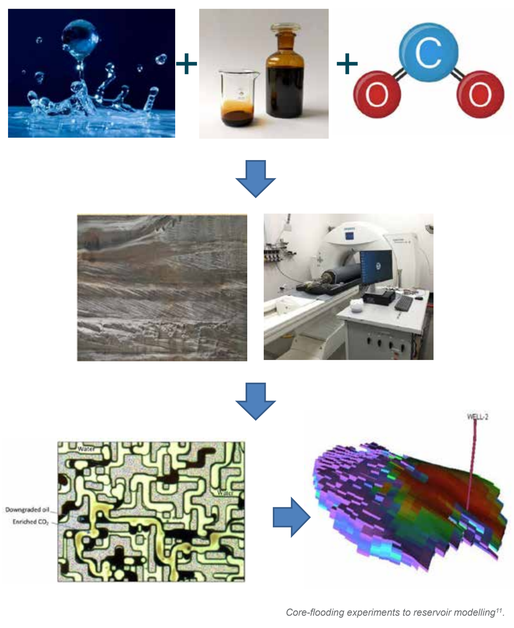
Our initial focus has been on brownfields, that is, ROZ targets near producing or depleted fields, in the Cooper-Eromanga basins in central Australia. In general, this area has suitable conditions for CO_2-EOR[10] and provides a mature, data-rich target for testing our geological and petrophysical work flow.

Early results indicate that there are several oil fields in this region with potentially significant ROZ.

Feasibility and quantification

Calibration and reservoir modelling

Core-flooding experiments

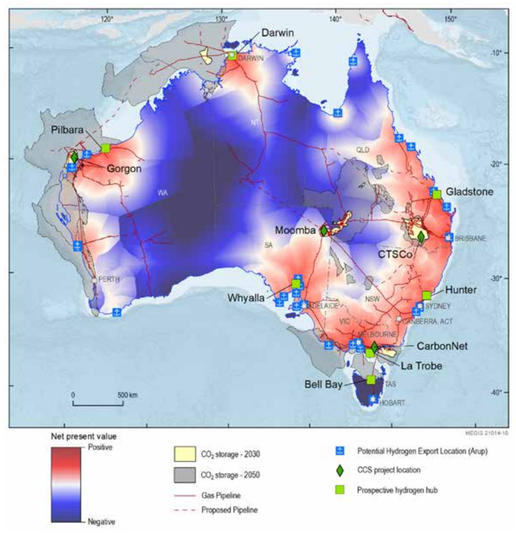


Core-flooding experiments to reservoir modelling[11].

Core flooding experiments[8] determine how miscible CO_2 will be with a given composition of oil, how efficiently the oil can be extracted using EOR techniques, and how much CO_2 can be stored in the reservoir.

The interactions between brine, oil and CO_2 observed in reservoir core samples combined with experimental results are then used to develop and calibrate reservoir models that can predict oil production and CO_2 storage efficiency in ROZ under various conditions.

CO_2-EOR and CCS economic fairways



Hydrogen economic fairways analysis (Geoscience Australia).

Geoscience Australia has developed the capability to model high-potential economic fairways for mineral resources and hydrogen production, shown above.

Economic fairway analysis for CO_2 storage and CO_2-EOR forms part of this project and will lead to the implementation of a multi-criteria techno-economic decision support tool for use by a range of stakeholders.

The hydrogen economic fairways tool (HEFT) is on display at this event at Geoscience Australia's booth, and can be accessed at ga.gov.au/heft.

Evidence from the USA shows that significant oil resources can be produced from ROZ through CO_2-EOR. Our work to date indicates that there may be opportunities for residual oil zone development in both mature hydrocarbon provinces and in underexplored basins. CO_2-EOR could help to both accelerate the CCS industry and secure domestic oil supply.

Key references

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Acknowledgements

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