Petroleum engineering: Unconventional gas reservoirs

CSIRO is developing innovative techniques to understand reservoir behaviour for efficient production from coal seam and shale gas reservoirs.

Gas storage and migration processes in unconventional reservoirs, such as coals and shales, are considerably different to those in conventional gas reservoirs. Gas is mainly stored as an adsorbed phase in coal, in contrast to conventional gas reservoirs where the gas is stored within the rock pores. In addition, coal is a 'dual porosity reservoir' with a microporous coal matrix separated by regular fractures (known as cleats) which form macropores.

The vast majority of the gas is adsorbed within the coal matrix and must desorb and then diffuse into the cleats as a first step in gas recovery.

An important complication in coal reservoirs is the tendency for coal to shrink with gas desorption and swell with adsorption. These changes in strain cause a geomechanical response that ultimately impacts on the permeability and therefore flow behaviour. Gas migration in coal seams is thus a coupled flow and geomechanical problem.

Expertise

The unconventional gas reservoirs team has a long established presence in this area, working on technical challenges associated with identification and drainage of coal seam gas. This is supported by several ongoing research programs with a strong track record in understanding gas migration mechanisms in coal. The team also has an excellent record of industry support. The main areas of expertise are:

- reservoir engineering
- site characterisation
- reservoir simulation
- coupled flow and geomechanical simulation.

The team can also undertake integrated reservoir characterisation using core samples to estimate the coal-specific reservoir properties required to apply reservoir simulators, significantly improving the reliability of simulator predictions.

Facilities

We have access to advanced facilities that house specialised equipment and technologies including:

- **an integrated laboratory facility for characterising coal seam permeability** – this facility is used to estimate the properties required to apply the coal permeability models used in reservoir simulation such as the Shi–Durucan and Palmer–Mansoori models. Properties estimated include coal cleat compressibility, coal sorption strain, geomechanical properties and adsorption characteristics.

Facility for integrated laboratory characterisation of coal seam gas.

- **core flooding rigs** – these multi-purpose rigs are used in a range of studies related to coal seam gas production. In one project the equipment was used to characterise the displacement mechanisms during enhanced coal seam gas production, in particular the multi-component gas diffusion properties used in reservoir simulation. In another application, this equipment was recently used to investigate formation damage associated with drilling muds. The core flooding rigs are also being used to characterise the stimulation of in-situ biogenic methane production as a method to increase the gas in place in coal seam reservoirs.

Core flooding rig for unconventional gas studies.

- **u-tube field laboratory** – this containerised field laboratory provides an automated reservoir fluids sampling system with gas composition analysis through gas chromatography. It can be used for a range of studies but is particularly suited to tracer gas studies with coal seam reservoirs. The u-tube is a system for recovering fluid samples from multi-phase reservoirs. These fluid samples are retrieved from the u-tube to a gas–water separator with the gas then going to a gas chromatograph for analysis.

Field laboratory for coal seam gas tracer studies.

- **multi-component gas adsorption rig** – this equipment measures the gas adsorption isotherm for multi-component gas mixtures, an important issue in characterising gas storage and production for many coal seam reservoirs.
- **SIMEDWin** – a commercial coal seam gas reservoir simulator, jointly developed with the University of New South Wales, School of Petroleum Engineering.
- **FLAMED** – coupled flow and geomechanical simulator for gas and water migration. This technology combines the coal seam reservoir simulator SIMEDWin with the geomechanical model FLAC3D to investigate the role of geomechanical processes during coal seam gas drainage.
- **CO_2 wellbore hydraulics modelling** – this model has been developed to represent wellbore hydraulics during CO_2 storage and includes the phase dynamics of multi-component gas mixtures allowing for thermal effects.

CO_2 injection during an enhanced coal seam gas field trial.

Applying the capability

CSIRO is conducting a large research program related to coal seam gas production, including:

- stimulation of in-situ methane production in coal seam reservoirs through microbial activity
- improved characterisation and prediction of coal seam reservoir permeability during gas production
- gas storage and recovery processes in coal seam and shale gas reservoirs
- enhanced recovery of coal seam methane through CO_2, N_2 or flue gas injection.

The technologies developed by the team have direct application for a broad range of problems related to managing gas drainage from coal seams. We can also perform integrated studies which encompass reservoir characterisation and simulation to identify optimal management strategies.

Our collaborators

We have successful collaborations with industry and other research groups to deliver project outcomes. We have partnerships with:

- industry on a range of projects including Santos, Origin, Queensland Gas Company, Arrow Energy, Shell
- Australian Coal Association Research Program
- University of New South Wales, School of Petroleum Engineering; The University of Western Australia; China University of Geosciences, Beijing.

Getting involved

Access to our capabilities and facilities can be acquired through commercial consulting services and products, or through research collaboration.

Enquiries can be made to Dr Luke Connell for further information.

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