CSIRO ENERGY
www.csiro.au

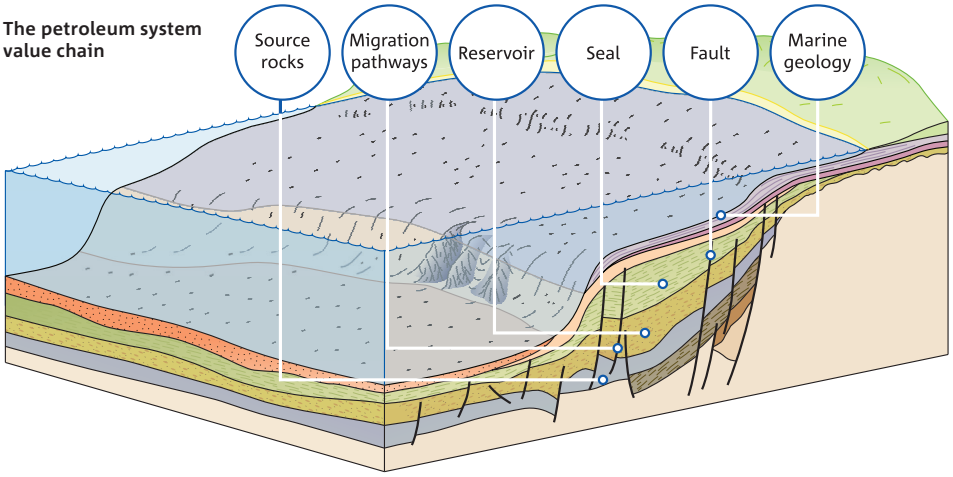
Petroleum exploration

CSIRO's petroleum exploration research spans from source rock characterisation through petroleum systems modelling, traps and reservoir characterisation, to faults and marine geology. This range of expertise and capabilities can be used to augment current industrial techniques and approaches to reduce exploration, development and production risks.

New scientific approaches and technologies developed by CSIRO and applied to oil and gas exploration have the potential to help discover new petroleum reserves, optimise oil and gas production for domestic use, and ensure the future competitiveness of Australia's petroleum industry.

CSIRO is applying knowledge of petroleum systems along the entire petroleum exploration value chain to help understand the source rock geological conditions leading to reservoir formation, hydrocarbon migration, seal integrity and fault reactivation.

The petroleum system value chain



Source rocks

Understanding the source rock is fundamental to defining a petroleum resource. Petrophysical and geophysical characterisation ranges from identifying and quantifying the rock mineralogy to understanding rock–fluid interactions and variations in seismic response. Petrophysical and geochemical characterisation expertise can be used in a range of ways to better define trapped fluids within the source rock, further detailing source rock character.

For example, fluorescence alteration of multiple macerals (FAMM) analysis, as well as specialist clay mineral analysis, can determine thermal maturity and source rock quality, leading to a better understanding of how the source rock has changed over time.

Combining this range of expertise and techniques with standard industry approaches allows for improved mapping of source rock potential.

CSIRO have developed a range of high pressure and temperature triaxial cells for testing shales and mudstones to understand rock–fluid interaction, deformation and acoustic response under geological stresses.

Migration pathways

CSIRO applies a range of innovative techniques to investigate the origin, evolution and migration of hydrocarbons in petroleum reservoirs and sedimentary basins. Through analysing fluid inclusions in conjunction with standard rock characterisation, migration pathways and reservoir history can be elucidated.

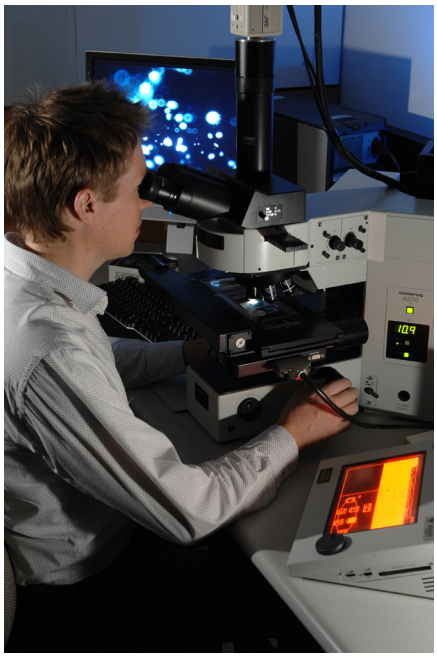
Fluid History Analysis (FHA) techniques developed by CSIRO combine microscopy, spectroscopy and geochemistry, and provide detailed information on oil migration and accumulation. The suite of analytical techniques includes Grains with Oil Inclusions (GOI™), Quantitative Grain Fluorescence (QGF), Total Scanning Fluorescence (TSF) and Resistivity from Oil–water Inclusions (ROI). These techniques have direct application in locating palaeo-oil zones with reliability and precision previously not possible, significantly reducing exploration risk in drilling and providing valuable calibration points for petroleum systems models.

Reservoirs

Research capabilities in petroleum geoscience are directed towards refining reservoir characterisation. Understanding diagenetic processes and their effects on reservoir quality is integral to oil exploration and production. CSIRO's expertise encompasses mineralogy, petrography, fluid inclusions, inorganic geochemistry, isotope geochemistry, organic geochemistry, organic petrology and reservoir modelling.

Fluid inclusion analysis coupled with detailed understanding of water chemistry and diagenetic processes is being used to better understand reservoir history through time, and how this impacts on reservoir quality. CSIRO is investigating the residual water saturation in gas fields using these techniques to more accurately quantify gas reserves, minimising the risks associated with investment and infrastructure decisions. Similarly, gas inclusion analysis can lead to a better understanding of the origin of any entrained CO_2, helping to predict the amount of CO_2 present and its effect on reservoir quality.

CSIRO also has extensive experience in sedimentary process modelling that can interpret past, present and future geological strata. Our comprehensive, process-based, stratigraphic forward model, Sedsim, has been extensively tested on the simulation of long-term sediment transport controlled by major depositional processes. Forward stratigraphic modelling can be used to simulate source and trap, and includes information about volumes of buried sediments, grain-size composition and porosity distribution, as well as the composition and thickness of overlying sediment packages. Sediment architecture responses and sensitivity can also be tested in different scenarios, providing useful information on possible stratigraphic sequences, composition and geometry. The results of these models can be used as an input to reservoir simulators or other basin modelling software to model various fluid flow processes.

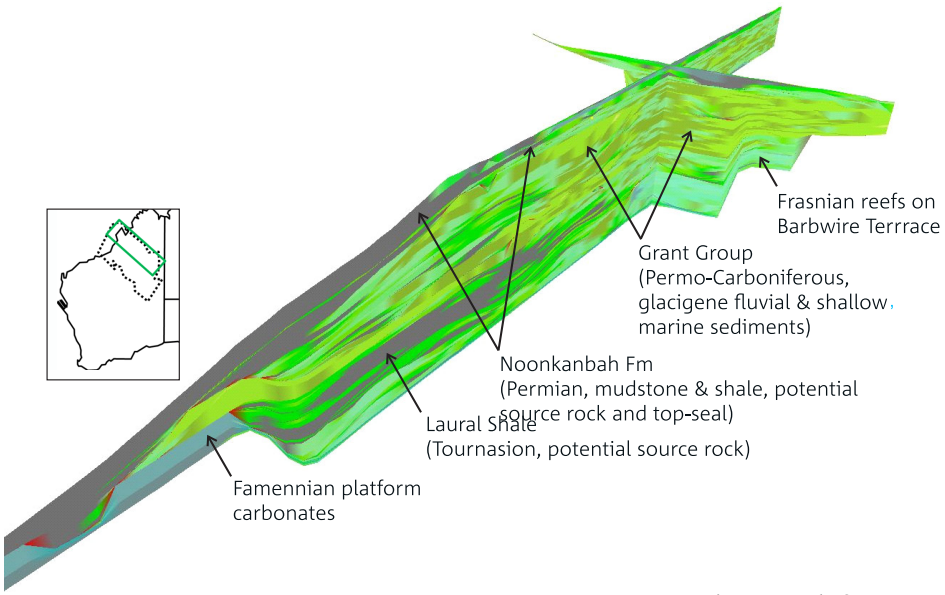


GOI™ technology can analyse oil inclusions to delineate migration pathways and history.

Software such as PressurePlot™, PressureQC and PressureDB™ has been developed by CSIRO to compile and compare contemporary and historical data sets. These can be used to analyse subsurface formation pressure, temperature and salinity data from reservoirs, further improving interpretation of the subsurface environment from existing data, and are especially useful in understanding deep hydrodynamic processes.

By integrating the tools and skills from multi-disciplinary areas of geoscience, CSIRO can work with industry to better characterise reservoirs, define impacts on reservoir quality, and help de-risk development and production decisions.

Integrating CSIRO's capabilities across the entire petroleum exploration value chain allows pre-competitive research to better characterise petroleum systems and reduce exploration risk. Equally these techniques, in combination with standard industry practices, can significantly de-risk development and production decisions by providing a better understanding of reservoir quality and behaviour.



Canning Basin Sedsim model. Perpendicular sections representing 100 My (375-275 Ma) of modelled deposition through the depocentre of the Fitzroy trough and Gregory Sub-basin structures. the long axis of the model is 900 km long.

Seals

CSIRO houses one of the leading geomechanics and rock physics laboratories in the world. Accurate analysis of rock mechanical properties is essential for the geomechanical characterisation of reservoirs, particularly understanding seal capacity and top seal integrity. Coupling this information with reservoir diagenesis and migration pathway information can inform where past losses may have occurred and the failure mechanisms involved. This in turn provides a better understanding of where fluids may have migrated to. Research on rock physics models also enables the development of more effective seismic inversion models for use in the industry.

Faults

A good understanding of faults and their ability to seal and create structural traps (or otherwise) can impact directly on exploration models. Combining an understanding of fault seals with fluid history analysis and migration pathway studies allows identification of the characteristics of traps that have breached in the past during burial of the formations. This information can be used to create better predictive models to identify likely prospects, while avoiding breached traps. This combination of techniques and expertise can be used to significantly de-risk prospects, prior to starting a drilling program. This workflow and experience has been successfully deployed in Timor Sea, Perth Basin and carbon capture and storage projects across Australia.

Marine geology

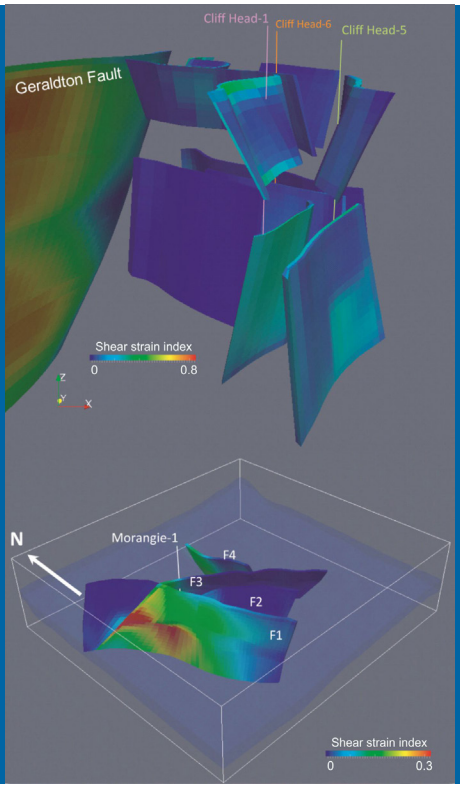
Seismic information can be combined with CSIRO's suite of hydrocarbon sensor and marine data collection systems in marine surveys of the water column to pinpoint hydrocarbon leakage from the seabed. Capturing and characterising leaked fluids can provide detailed information on reservoir hydrocarbons, from the characteristics of the source rock, to the location of historical migration pathways, and secondary alteration characteristics; all prior to drilling. All of this can then inform the exploration approach, minimising risk. Linking marine geology with fault seal studies can further de-risk drilling decisions.

Case study – Reducing exploration risk in the offshore northern Perth Basin

CSIRO worked in collaboration with Geoscience Australia (GA) to better understand the prospectivity of the offshore northern Perth Basin, after a failed drilling program by Roc Oil resulted in the acreage being re-released in 2011. Studies CSIRO had performed for Roc Oil on oil migration and accumulation (using FHA techniques) showed that the Basin had laterally extensive and world-class source rock, ideally suited to oil generation, but also showed that oil accumulations had subsequently been lost in about 80 per cent of the wells analysed.

CSIRO and GA then investigated trap seal integrity, to understand why failed traps were so commonly found in the Basin. 3D geomechanical modelling showed that fault reactivation was found to be a major cause of trap failure, but also explained why some traps were protected against critical damage caused by fault movements, and preserved their oil accumulations (including Roc Oil's initial successful Cliff Head oil field). Identifying the key risk factors made it possible to target specific trap styles that are not as susceptible to fault reactivation and breach.

This pre-competitive research resulted in a dramatic re-rating of the prospectivity of the region, and competitive bidding for the acreage resulted in an new industry investment of at least $70 million for exploration in the area.



3D shear strain distribution showing the shielding effect of the Geraldton Fault on the Cliff Head oil field bounding faults.

3D shear strain distribution showing deformation/ reactivation loci on the dry Morangie structure bounding faults.

Partners

Although applications are directed primarily at petroleum exploration and production potential, petroleum research is also relevant to understanding sedimentary basin and crustal evolution and for progressing emerging industries in geothermal energy and geological storage of CO_2.

CSIRO aims to augment and support existing industry approaches and techniques, through developing complementary technologies and knowledge frameworks. CSIRO partners nationally and internationally with:

- federal and state agencies
- national and international oil and gas companies
- small and medium enterprises
- the global research community
- the Western Australian Energy Research Alliance (WA:ERA) and its industry partners Chevron, Woodside and CGG Veritas
- Australian National Low Emissions Coal Research & Development (ANLEC R&D).

Our partnerships ensure a rapid and effective path to implementation of our research outcomes.

Getting involved

For further information about CSIRO's specific petroleum exploration research activities and capabilities along the entire petroleum exploration value chain, contact Andrew Ross.

For additional information see the CSIRO brochures on:

- Argon Thermochronology
- Diagenesis Characterisation
- Dielectric Measurement

CSIRO applies gas geochemistry and isotopic analysis to issues in exploration and production of gas.

- Fluid History Analysis
- Hydrodynamics
- Organic and Isotope Geochemistry
- PressurePlot
- Rock Mechanics
- Shale Research Centre.

Key contacts

Dr Ben Clennell
Team Leader
Oil, Gas & Fuels Program
t +61 8 6436 8599
e ben.clennell@csiro.au