

# Shale Research Centre

Conducting experimental and theoretical research on shale properties and problems.

The CSIRO Shale Research Centre, located at the Australian Resources Research Centre in Perth, Australia, is a nucleus of experimental and theoretical research expertise aimed at solving the critical issues related to clay rich sediments and rocks for the petroleum industry.

Shale-related problems include wellbore stability, pore pressure prediction, seal integrity and seismic imaging. A better understanding of clay and shale behaviour can save the petroleum industry billions of dollars. Such knowledge is also applicable to the waste disposal industry and to groundwater issues such as managed aquifer recharge.

## Industry services

The Centre provides a range of services and research partnership opportunities to industry including:

- ♦ full membership
- ♦ partnership in the Shale Research Centre (SHARC) Consortium
- ♦ partnership in specific projects
- ♦ commercial services
- ♦ secondment and staff exchange programs.

## Facilities

### GEOMECHANICS LABORATORY

CSIRO's world-class geomechanics laboratory houses numerous rigs equipped for high confining and pore pressures, high axial loads and elevated temperatures. Many rigs are equipped with ultrasonic transducers for the simultaneous measurement of P- and S-wave velocity during testing, including the full elastic tensor under load on single samples.

### PETROPHYSICS LABORATORY

The laboratory incorporates a helium porosimeter/permeameter, nuclear magnetic resonance spectrometer (NMR) with pressure core holders, a computed tomography (CT) scanner,

and can analyse low and high frequency electrical properties under in-situ pressure conditions. CSIRO also has access to high frequency NMR rigs, high resolution X-Ray CT scanning, the OPAL neutron scattering source and the Australian Synchrotron.

### NMR SPECTROSCOPY LABORATORY

This facility has high-field NMR instruments capable of solid-state analysis and two low-field instruments for routine analysis of molecular dynamics in both the solid and liquid state and conducts research and development to characterise materials by solution and solid-state NMR spectroscopy.

### MODELLING

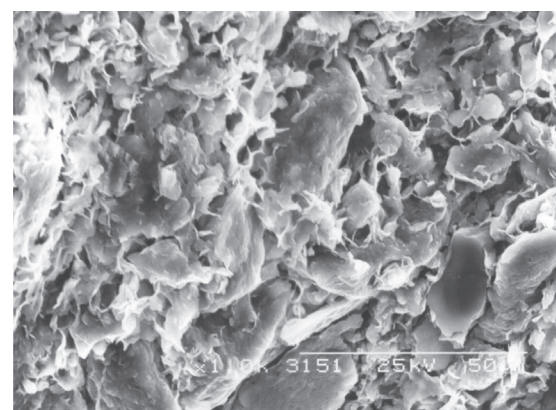
Rock physics modelling and combined dynamic elastic and electrical properties modelling aim to build microstructural models that will simulate elastic and viscoelastic properties of shales (in particular, anisotropy and attenuation) as functions of mineralogy, confining stress, stress anisotropy and pore pressure.

### MINERALOGICAL AND GEOCHEMICAL SERVICES LABORATORY

This laboratory applies specialist expertise and state of the art instrumentation to the identification and characterisation of minerals in soils and rocks using X-ray analysis techniques. The laboratory uses the Rietveld method of quantitative X-ray diffraction (XRD) analysis and also specialises in the identification and quantification of clays and clay minerals.

### CUTTINGS ANALYSIS LABORATORY

The laboratory develops novel methods for using drill cuttings to determine mechanical properties of rocks, including the coupled chemothermoporomechanical properties that characterise the interaction between drilling fluids and shale formations, wave speed and dielectric constant.



Scanning electron microscopy images of shale microstructure aid understanding of geomechanical properties and rock physics response.

## Centre objectives

- ♦ To become a global hub for shale research and development
- ♦ to develop new methods for shale characterisation
- ♦ to develop laboratory-to-field methods for predicting shale properties spatially
- ♦ to gain a fundamental understanding of the nature of water in shales
- ♦ to develop integrated, cohesive models for prediction of shale properties.

## Expertise

CSIRO has more than 20 years experience in shale-related research and development, including experimental and theoretical evaluation of shale properties and numerical modelling and simulation applied directly to industry-based problems. World-class rock mechanics, rock physics and petrophysics laboratories are located in Perth, Sydney, Adelaide and Melbourne. Expertise also exists in theoretical rock physics as well as analytical and numerical rock physics and electrical modelling.

## Current projects

### SHARC2 CONSORTIUM

An industry co-funded joint industry project investigating links between mechanical, dynamic elastic and petrophysical properties accounting for organic matter and partial saturation, using a micro-to-macro, laboratory-to-field, experimental-to-theoretical approach to solve critical issues in clay-rich rocks that are applicable to the petroleum and waste disposal industries.

### SHARC CONSORTIUM

An experimental and theoretical project that has extensively tested shale samples from around the world in terms of rock mechanical, petrophysical and rock physics properties. New workflows have been developed for shale characterisation, correlations between properties established and novel rock physics models developed to predict elastic properties from mineralogy and porosity.

### WATER RESOURCES

Characterisation of mechanical and physical properties of smectite-rich clay and shale aquitards in Australia's Great Artesian Basin in order to better understand and model local and regional groundwater flow.

### NATIONAL GEOSEQUESTRATION LABORATORY (NGL)

Design and manufacture of new equipment for rock mechanics and permeability testing of shale seals with long exposure to supercritical CO<sub>2</sub>. Development of methods, workflows and models for shale response to supercritical CO<sub>2</sub> exposure.

### AUSTRALIAN NATIONAL LOW EMISSIONS COAL (ANLEC R&D)

Determination of the mechanical and physical properties of shales recovered from National CO<sub>2</sub> Flagship geological storage sites in order to develop models for containment integrity as well as monitoring and verification for sequestered CO<sub>2</sub>.

## INDUSTRY PROJECTS

Extensive rock mechanical and rock physics testing over more than 20 years on sandstones, shales and carbonates from Australasia and basins worldwide. Numerous petrophysical tests have also been conducted for industry on shales, sandstones and carbonates, involving NMR, CT scanning, poro-perm measurements and electrical properties.

## Recent achievements

### CHEMOPOROMECHANICAL PROPERTIES PATENT

A portable rig-based apparatus and method characterising shale formations using drill cuttings to determine how drilling fluids and shale formations will interact. The information can be used to modify drilling fluids – based on engineering analysis – to minimise wellbore instability.

### IPETS CONSORTIUM

An industry co-funded consortium aimed at reducing exploration risks associated with traps and seals. The program has investigated the geomechanical, rock physical and petrophysical response of shales to changing stress conditions, and wettability in clay-rich systems through petrophysical and surface chemistry approaches. Correlations to shale strength were developed along with unique experiments investigating wettability in clay-rich systems.

### DIELECTRIC PROJECT

An industry-funded project developing new test methods to investigate the dielectric response of shales and sandstones. Techniques were devised to develop synthetic dielectric logs from shale cuttings for comparison with downhole logs, including understanding the impact of pyrite on petrophysical measurements.

### CO2CRC

Experimental determination of sandstone and shale mechanical and dynamic elastic properties for

application to both seal integrity and monitoring, and verification at a pilot site for CO<sub>2</sub> injection.

## Our clients

The Centre has an extensive list of Australian and international industry partners and clients. These include Exxon-Mobil, Chevron, Woodside, BP, Statoil, Total, Santos, Origin Energy, BG-Group, QGC, Petronas, Petrobras, Sinopec, Saudi Aramco and ConocoPhillips.

## Industry benefits

Industry will benefit from the key strengths of the Centre, including:

- ◆ multi-disciplinary research teams with access to a range of capabilities within CSIRO
- ◆ a dynamic experimental and modelling approach to research
- ◆ world-class experimental laboratories
- ◆ renowned, experienced researchers
- ◆ an excellent track record of delivering research outcomes that directly benefit industry
- ◆ significant investment leverage through CSIRO's National Research Flagship Program.

## Key contacts

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