

# Petroleum geoscience: Organic and isotope geochemistry

The organic and isotope geochemistry group conducts research into issues related to exploration and production of petroleum.

The team is focussed on the molecular and isotopic characterisation of petroleum, evaluation of the quality and thermal maturity of potential source rocks, exploration/production of coal seam gas, petroleum microbiology, tracer gas analyses for gas storage and carbon dioxide (CO<sub>2</sub>) sequestration projects, and enhancement of oil and gas recovery by microbial treatment. We develop and apply organic geochemical techniques to meet these objectives.

## Expertise

Our team has expertise in molecular and isotopic analyses of petroleum and other organic substances.

We provide:

- ♦ oil–oil, oil–gas and oil–gas–source correlations
- ♦ oil generative potential of source rocks
- ♦ comparisons between oil maturities
- ♦ identification and quantification of secondary alteration events
- ♦ identification and quantification of mixing processes
- ♦ insights into basin fill history and reservoir processes, and stepwise fill history, by analysing the molecular and isotopic composition of petroleum trapped in fluid inclusions
- ♦ analysis of trace level target compounds such as microbial metabolites, toxins or drugs and organic contaminants
- ♦ migration, monitoring and verification of CO<sub>2</sub> plumes during carbon capture and storage.

## Facilities

CSIRO has state-of-the-art facilities and equipment to carry out analyses for research and commercial purposes.

## Instrumentation

- ♦ Thermo Fisher Scientific DFS high resolution gas chromatography–mass spectrometry (GCMS)
- ♦ Thermo Electron DELTA V Plus isotope ratio mass spectrometer (IRMS) interfaced to an Agilent 6890 GC, with access to a temperature conversion – elemental analyser (TC-EA) inlet system on the same instrument for the measurement of H and C isotopes on gases, solids and liquids
- ♦ two benchtop GCMS instruments (Agilent 6890 GC interfaced to MSD 5973, Agilent 7890 GC interfaced to MSD 5975C), additional detectors (flame ionisation detection (FID), electron capture detection (ECD))
- ♦ laser microprobe unit interfaced to GCMS equipment: highly specialised and custom-built equipment using a Nd:YAG laser beam to extract geochemical information from microscopic entities, eg macerals, solid bitumen phases and microfossils
- ♦ three GCs dedicated to the molecular analysis of gases (Varian CP4900 Micro GC, Agilent 6890N natural gas analyser (NGA) and a Varian 3800 NGA)
- ♦ access to Leco Pegasus GCxGC-time of flight (ToF) instrument, hosted at Macquarie University
- ♦ access to high performance liquid chromatography (HPLC), LC–MS, solid phase micro-extraction (SPME)–GCMS, Finnigan MAT 252 IRMS + Europa Roboprep CN Elemental Analyser (EA) via a Finnigan ConFlo III and Dionex accelerated solvent extraction (ASE) system
- ♦ excellent wet chemistry facilities with all the required apparatus, various vacuum manifolds and dedicated fluid inclusion work area
- ♦ two GC–FID instruments for routine and whole oil analyses (Varian 3400)
- ♦ state-of-the-art gas line installations with gas sensors to maximise gas safety in the laboratory.

## Case study

### WORLD'S OLDEST OIL

In collaboration with Sydney University, Colorado State University, USA and the University of Washington, USA, CSIRO has developed techniques to enable clean and unambiguous data on the chemistry of some of the world's oldest oils.

The oil has been preserved inside fluid inclusions for more than two billion years in minerals of the Matinenda Formation, Canada.

Despite high temperatures (>300°C) after oil migration, biomarkers that give evidence on the evolution of early life on Earth have been detected in this oil. These ultrasensitive techniques have also been applied to refine petroleum exploration and fill history concepts in Australia and other parts of the world.



Petroleum-filled inclusion in quartz.

## Analyses

- ◆ Identify biomarkers and other trace level organic compounds using full scan, selected ion monitoring (SIM) and specific parent/daughter ion relationships such as multiple reaction monitoring (MRM) experiments
- ◆ determine stable carbon and hydrogen isotopic composition of gases and compound-specific carbon isotopic composition of n-alkanes
- ◆ identify and characterise gaseous and volatile organic compounds using GC coupled with a range of detectors (FID, TCD, ECD, MSD)
- ◆ fractionate crude oil or extract into aliphatic and aromatic hydrocarbons, polar compounds, n-alkanes and branched/cyclic hydrocarbons
- ◆ derivatise functionalised organic compounds (eg lipids) and analyse microbial metabolites.



Preparing a gas sample for carbon isotopic analysis.

## Applying the capability

The organic and isotope geochemistry team applies molecular and isotopic analyses to issues in exploration and production of oil and gas.

We can identify processes that have occurred in reservoirs and along migration pathways (including selective migration, geochromatography, water washing, biodegradation, deasphalting and thermal and catalytic cracking).

The team has a long track record in interpreting isotopic and molecular information in a geological context. For example, knowing that a gas discovery contains both thermogenic and biogenic gas may open an area up for thermogenic gas exploration in parts of a basin where this potential has not been recognised before.

CSIRO also has extensive capability in microbially enhanced coal seam methane (MECSM) research and the analysis of organics in water associated with unconventional gas resources.

### Case study

We analyse gases for novel tracers (e.g. fully deuterated methane, CD<sub>4</sub>) and more conventional tracers (e.g. halogenated compounds SF<sub>6</sub> and R-134a, noble gases) for samples associated with the CO<sub>2</sub>CRC Otway Project site. The Otway Project is Australia's first demonstration project of the deep geological storage of CO<sub>2</sub>, and our tests contribute to the monitoring and verification of CO<sub>2</sub> movement in the subsurface. Similar tests can also be conducted for hydrocarbon gas storage projects.

## Our collaborators

The team works closely with a number of research collaborators within and beyond CSIRO:

- ◆ national and international energy companies: e.g. Chevron, PETRONAS, Woodside, Exxon–Mobil, Petrobras, Interoil, Origin, Roc Oil, BP Exploration & Production Inc
- ◆ State and Federal agencies: e.g. Geoscience Australia, Victorian Department of Primary Industries
- ◆ universities and research centres: e.g. Macquarie University, Curtin University, RWTH Aachen/Germany, GNS Science/New Zealand, Cooperative Research Centre for Greenhouse Gas Technologies (CO<sub>2</sub>CRC), Geoforschungszentrum Potsdam, Laser Zentrum Hannover
- ◆ service companies: e.g. Environmental Isotopes Pty Ltd, ACS Laboratories, Geotechnical Services, Earth Data.

## Getting involved

Projects can be commissioned as jointly funded collaborations or as fee-for-service contracts, depending upon the nature of the work.

We can provide data which can be supplemented with interpretation, reporting and additional advice, or training if requested.

### Key contact

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