Petroleum geoscience: Diagenesis characterisation

CSIRO applies an array of technologies to deliver capabilities in diagenetic studies and the characterisation of reservoir rocks and minerals.

Understanding diagenetic processes (changes occurring within sediments after their original deposition, particularly tectonic history and the nature and types of fluids that have circulated through them) and their effects on reservoir quality and the physical and chemical properties of rocks and minerals is integral to oil exploration and production. Diagenetic processes are also relevant to CO_2 geological storage, mineral exploration and waste disposal.

Diagenesis influences reservoir properties that are critical for optimising oil production and recovery. For example, the formation of highly cemented layers close to faults can act as internal seals, resulting in compartmentalisation of the reservoir and localised over-pressured zones. In contrast, specific mineral cements can preserve reservoir porosity and permeability even at great depth. Comprehensive understanding of diagenetic patterns and their occurrence, coupled with routinely-used sedimentological models, leads to enhanced predictive models for improved oil field development.

CSIRO combines extensive experience with a large range of technologies to conduct comprehensive studies of diagenetic processes.

Expertise

Our expertise encompasses mineralogy, petrography, fluid inclusions, inorganic geochemistry, isotope geochemistry, organic geochemistry, organic petrology and reservoir modelling. We integrate a range of skills and experience in these fields to:

- identify and quantify rock mineralogy
- understand and date cement sequences
- define the nature, composition and temperature of formation fluids
- reconstruct thermal evolution of target formations
- model diagenetic processes.

Microscopy as an investigation tool for reconstructing diagenesis fluid circulations and oil entrapment.

Our capabilities

CSIRO research facilities house a wide range of specialised equipment to provide services from basic data acquisition through to performing fully-integrated studies. The diagenesis team have capabilities for:

- X-ray diffraction (XRD) and Fourier transform infra red (FTIR) analyses for mineralogy of bulk rocks or clay fractions
- petrographic analysis using optical microscopy, and scanning and transmission electron microscopy to establish diagenetic history
- reconstruction of fluid and thermal evolution
- definition of predictive diagenetic models at the field scale
- definition of fluid flow pathways and reservoir compartmentalisation
- reconstruction of oil migration pathways and timing
- determining timing and tracing of diagenetic events using K–Ar and ^{40}Ar–^{39}Ar dating, $^{87}Sr/^{86}Sr$ isotopes and stable isotopes (O, C, H).

The study of diagenetic processes involves integrating multiple techniques to characterise variations in mineralogy and fluid composition, and to determine the evolution of pressure and temperature.

Our team delivers a better understanding of diagenetic processes by applying:

- an array of petrographic techniques to characterise, quantify and reconstruct the genetic history for minerals, cements and porosity
- fluid inclusion studies
- elemental geochemistry to:
  - calculate mass balances
  - simulate diagenetic reactions
  - identify provenance
  - understand fluid circulations within reservoirs and compartmentalised reservoirs
- isotopic geochemistry to:
  - characterise the nature of fluids from which cements originated
  - identify sources and mechanisms controlling formation of cements
  - estimate temperature of cement formation
  - reconstruct fluid circulations within reservoirs
- isotope dating to:
  - obtain time markers for the formation of specific cements
  - reconstruct time–temperature history
- organic geochemistry of rock extracts and fluid inclusions for assessing source, thermal maturity and secondary alteration of the oils. This information is important to track petroleum source rocks, characterise the charge history of petroleum reservoirs through geologic time, and calibrate basin models
- organic petrology, including fluorescence alteration of multiple macerals (FAMM) analysis to determine thermal maturity and source rock quality
- modelling to integrate all the available information at reservoir-, field- or basin-scale.

Case study

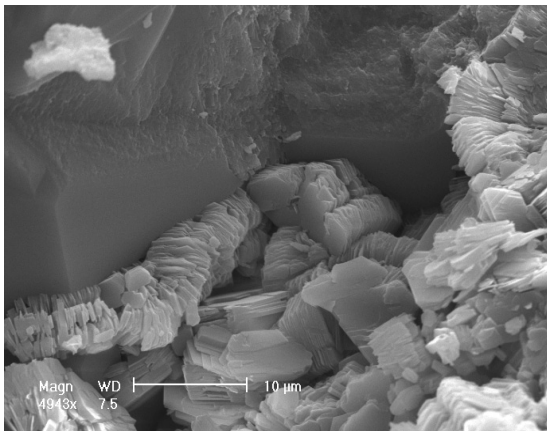
Our team has been working on reservoir diagenesis in the Sydney Basin (NSW), the Cooper–Eromanga Basin (SA), the Officer Basin (WA) and the North West Shelf (WA). Other studies have been completed for reservoirs located in the Tarim Basin (China), the North Sea (Europe), Rotliegendes (Germany), the Camaquã Basin (Brazil) and Saudi Arabia.

Our partners

CSIRO has developed partnerships with research groups in Australian universities, such as Curtin University, The University of Western Australia and Macquarie University, and other organisations such as the Western Australian Energy Research Alliance (WA:ERA), Geoscience Australia and the CRC for Greenhouse Gas Technologies (CO2CRC). Industrial partners include numerous international oil and gas companies.

Getting involved

The diagnesis team provides efficient and reliable services, backed by an experienced and knowledgeable team, available for research and commercial projects. For more information on how the team can work with your organisation, contact Andrew Todd.



Secondary electron view of a kaolinite cemented sandstone.

Key contacts

Andrew Todd
Senior Researcher
Onshore Gas Program
t +61 8 9266 2796
e andrew.todd@csiro.au

Dr Neil Sherwood
Group Leader
Onshore Gas Program
t +61 2 9490 8976
e neil.sherwood@csiro.au