Petroleum geoscience: Argon thermochronology

CSIRO's argon thermochronology team applies K–Ar and ^{40}Ar–^{39}Ar dating technology to determine the ages of rocks, minerals and the timing of fluid flow. This provides crucial information to improve understanding of exploration targets for the petroleum industry.

The development of new technologies to maximise successful exploration and reduce risk is a key focus for the oil and gas industry. Successful exploration relies on knowledge of basin formation and the thermal history of sedimentary rock and hydrocarbon migration. Understanding the time in which these events have occurred is vital for efficient exploration, as they provide clues on the rate of charge in a reservoir; and oil and gas migration.

The CSIRO argon laboratory is the only facility in the southern hemisphere that applies argon thermochronology to sedimentary rock.

Expertise

Our team has more than 15 years of expertise in the field of argon thermochronology in sedimentary environments for hydrocarbon exploration. We are involved in developing innovative research solutions in all aspects of argon geo- and thermochronology, and the transfer of knowledge and capability to the oil and mining industries, as well as within academia.

Facilities

CSIRO has a range of state-of-the-art equipment for K–Ar and ^{40}Ar–^{39}Ar dating, including the first micro-encapsulation station to date clay minerals by ^{40}Ar–^{39}Ar dating. Our facilities are located at the John de Laeter Centre for Mass Spectrometry at Curtin University, and include:

- high-resolution noble gas mass spectrometers, with online extraction and purification lines
- a double vacuum resistance furnace
- a 6 mJ ultra-violet 213 nm pulsed laser, capable of high-resolution ablation (15–300 µm spot size)
- a clay mineral separation laboratory with high speed centrifuges and equipment for freeze–thaw disaggregation of rocks.

Applying the capability

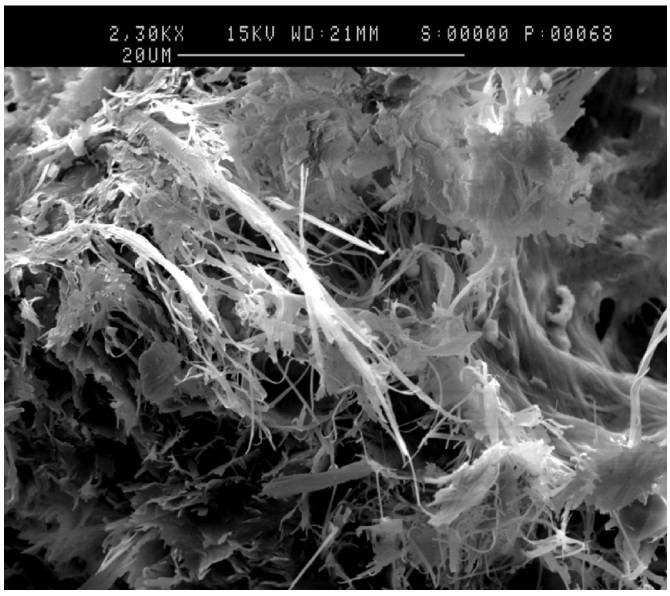
The team applies dating techniques to illite, a clay mineral common in many sedimentary rocks. Illite dating is an important tool for the petroleum industry as it can provide a K–Ar isotope date that constrains a heating and/or fluid flow event within a basin. Illite is often the last mineral formed prior to hydrocarbon charge, therefore illite dating can provide an estimate of when hydrocarbon charge occurred.

Distribution and age profiles of illite also give an indication of the duration and nature of the charge. Based on this data, assessments of the reservoir quality can be made.

In addition, illite is a common mineral formed during deformation events. Faults may act as a conduit zone, controlling fluid flow, or act as a seal, restricting fluid flow. The migration of hydrocarbons can be better predicted by examining the timing of faulting and deformation events. Illite dating can be used to determine:

- timing, duration and nature of hydrocarbon charge
- timing of hydrocarbon migration and entrapment
- timing of diagenetic events
- correlation of formations
- timing of deformation events
- timing of tectono-thermal events
- age provenance of detrital minerals.

Knowing the age of illite formation will facilitate the construction of reliable geological models of basin histories. This will enable oil and gas companies to better determine potential locations for drilling petroleum wells.



Secondary electron microscope image of authigenic fibrous illite occurring in deeply buried reservoir sandstones of the Cooper Basin, Australia.

Case study:

Cooper Basin, Australia

K–Ar dating of illite in the sandstones of the Cooper Basin has made it possible to develop a timeline of significant events in the Basin's evolution. K–Ar dating of specific illite samples from different stratigraphic units, depths and grain sizes reflect the timing of when hydrocarbon expulsion occurred in the Basin. The timing of the meteoric flushing due to the uplift and erosion caused by a major unconformity was also predicted using K–Ar dating of particular illite samples present in the Basin.

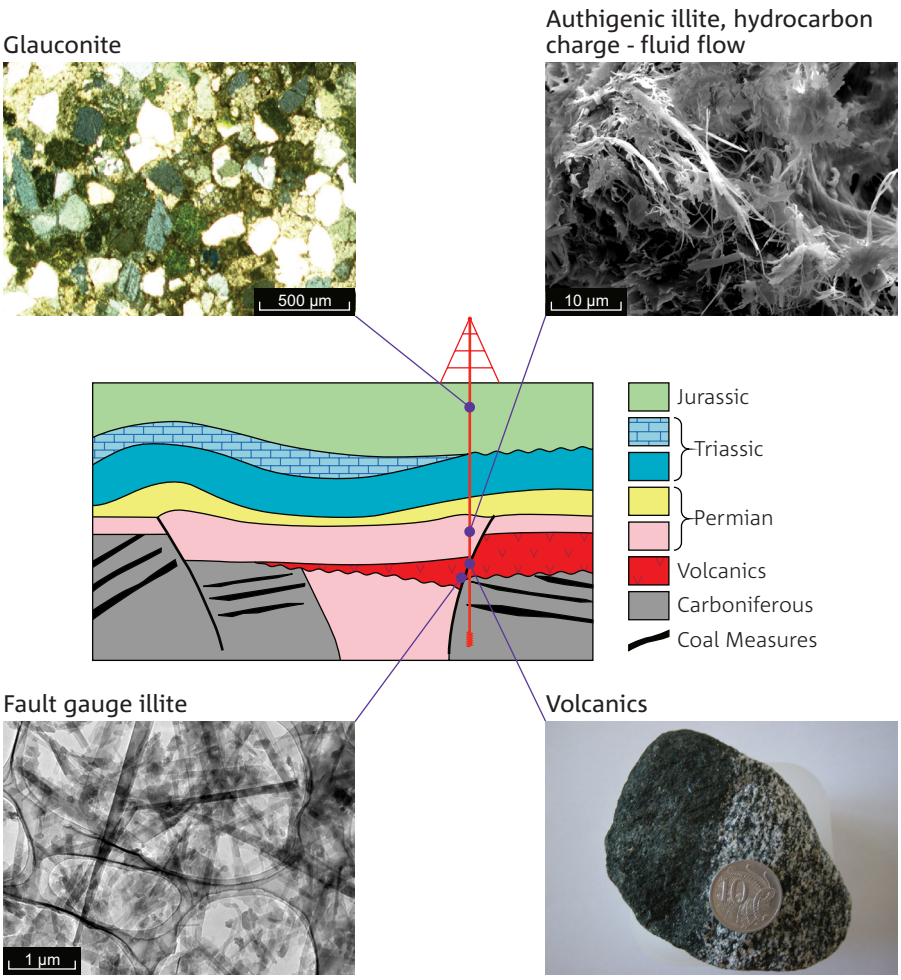
Getting involved

Services available for research and commercial purposes include:

- X-ray diffraction, scanning and transmission electron microscopy, particle size analysis for clay characterisation
- diagenetic history by detailed petrography studies
- general diagenesis investigations including petrography and diagenetic sequences
- vacuum encapsulation for ^{40}Ar–^{39}Ar dating of clays and fine-grained samples
- stable and radiogenic isotope analysis.

K-AR	^{40}AR-^{39}AR
Fast screening tool beneficial for commercial purposes.	Screening for longer-term exploration. Slower turn around time due to irradiation process
Screening of large samples ~30-100 mg	Screening of small samples <~50 mg
Size separation - potential contamination	Identification of different generations-contamination
Size fraction age information	Laser ablation permitting in situ sampling
Indirect T information	Coupled direct t/T information
	Encapsulation to address ^{39}Ar recoil

Benefits of K–Ar and ^{40}Ar–^{39}Ar dating



Schematic cross-section of a sedimentary basin illustrating potential applications for K–Ar and ^{40}Ar–^{39}Ar dating.

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