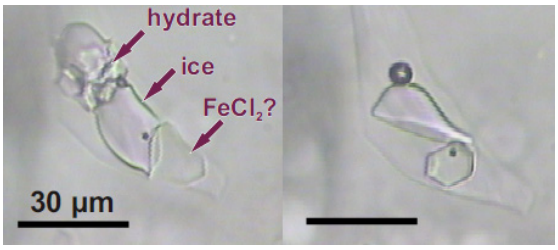
Pore Scale Solutions

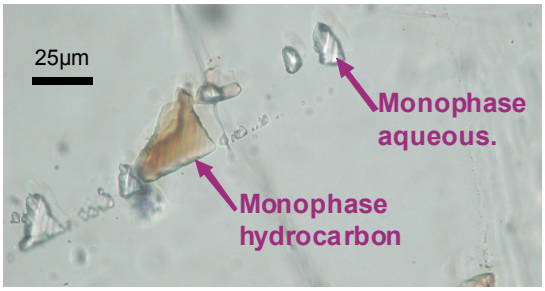
Fluid Inclusion Analyses

Screening: Prior to microthermometric analysis any available routine thin-sections are screened using transmitted polarised light microscopy to assess the abundance, nature and distribution of inclusions within the phases of interest and their suitability for microthermometric analysis. Depending upon the project aims, a number of different mineral phases within either the sediment and/or within fracture systems might be considered.



Sample Preparation: Once suitable samples have been identified, doubly-polished wafers are prepared using standard techniques ensuring that they are not overly heated or otherwise stressed during preparation, to minimise any disruption to the inclusions that may occur due to leakage and/or annealing. On project completion, the wafers (minus the small fragments extracted for microthermometric analysis; see below) are returned to the client. The ideal parent sample material would be conventional core samples. We can work with sidewall cores, and sometimes cuttings - although we have to much more alive to the possibility that the inclusions / fluids have been perturbed by drilling / coring.

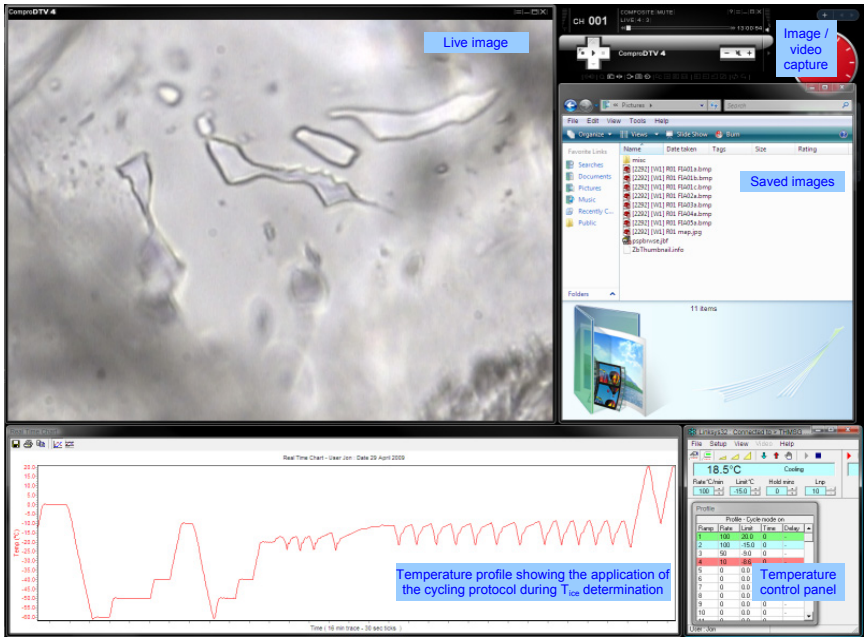
Petrography: Detailed fluid inclusion petrography is then carried out using both transmitted and reflected ultraviolet illumination (epifluorescence). This provides information on the distribution, size, timing (primary versus secondary), degree of fill, and nature (e.g. aqueous or hydrocarbon [including an estimate of API gravity where possible]) of the inclusions and on any relationships between different inclusion populations. Specific areas of the sample containing the most prospective inclusions are identified and documented prior to microthermometric analysis.



We can also carry out additional analyses to resolve multiple generations of individual diagenetic phases (e.g. optical cathodoluminescence to resolve different generations of carbonate, or SEM-cathodoluminescence to resolve different generations of quartz), and relate these to the fluid inclusion petrography. Consideration is given to the impact of these additional analyses on the integrity of the fluid inclusions - for example, optical cathodoluminescence causes heating, which may cause inclusions to leak or burst and therefore should not be carried out on inclusion wafers prior to microthermometric analysis. It can, however, be applied to counterpart standard polished thin-sections and/or, post-microthermometry, to the fragments actually analysed.

Microthermometry

The most prospective areas of the sample are extracted from individual wafers using fine cutting tools (typically a fragment of a couple of mm diameter is extracted leaving the remainder of the sample intact), and then loaded into the heating-freezing chamber for microthermometric analysis.



For the determination of all phase changes a "cycling" protocol, consistent with best-practice for the study of fluid inclusions in diagenetic cements is applied, and consideration is also given to the impact the actual measurements may have on the inclusion(s) under consideration - for example, the formation of ice in relatively soft minerals such as calcite can cause inclusions to stretch, meaning that homogenisation temperatures have to be collected before any "freezing-runs" are carried out. Inclusions are constantly monitored for signs of leakage during analysis.

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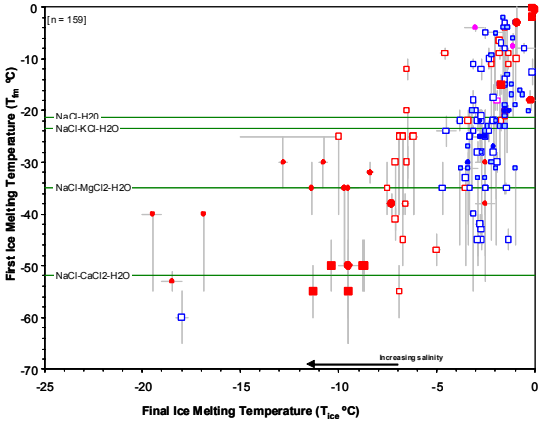
Depending upon the specifics of the project and the nature of the inclusions present, the microthermometric analyses will attempt to determine the temperatures at which some combination of the following phase changes occur in the inclusion fluids:



- Homogenisation temperature: which gives an estimate of minimum temperature of trapping in primary inclusions. In combination with independent estimates of pressure during mineral formation, this can also be used to model actual trapping temperatures.
- First ice-melting temperature: which gives an indication of the speciation of components within the fluid (e.g. NaCl vs. $CaCl_2$ dominated).
- Final ice-melting temperature: which can be used to model the bulk salinity of the fluid. When combined with first ice melting data, a more detailed model of the nature of dissolved salts can be established (e.g. NaCl:$CaCl_2$ ratios).

We spend approximately one day per sample during which we collect as much microthermometric data as possible. It is normally possible to acquire data from approximately 10-20 inclusions from each sample within this time, although the actual number of inclusions analysed will be dependant upon their abundance, distribution and complexity. In cases where the inclusions show considerable complexity, additional time may be recommended/required in order to derive meaningful data.

Interpretation and Reporting: The raw microthermometric data are evaluated and used to model salinities, trapping temperatures etc. for the individual inclusions. These data are then interpreted in the context of the background petrographical and fluid-inclusion information, along with any burial and filling histories provided by the client, to provide insights into the fluid and thermal history of the system from which the samples are derived.

All results are presented in fully illustrated technical reports that are provided digitally (both as a compiled pdf, and in MS office formats).. Digital photomicrographs captured and documented throughout all stages of any project are also supplied in standard image formats (tiff, jpg, bmp).

Facilities

Our in-house facilities include:

- Zeiss Axioskop50 microscope with transmitted plane polarised and reflected uV (epifluorescence) illumination. This microscope can also be re-configured for reflected light illumination of opaque phases.
- Computer-controlled Linkam THMS600 fluid inclusion heating-freezing system.
- Canon digital camera for capture of digital photomicrographs.
- Video camera system for live imaging during microthermometry.