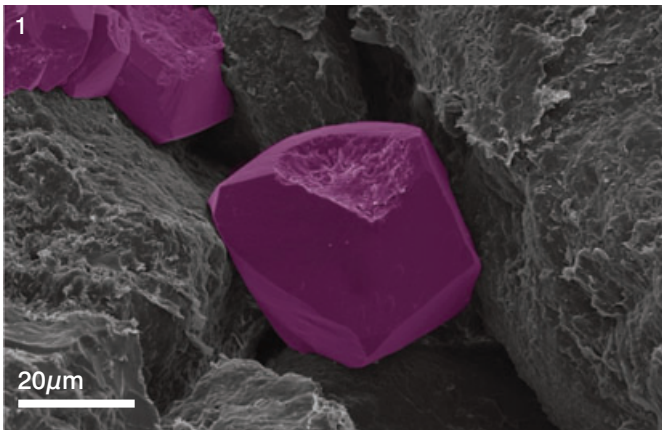
University of Glasgow

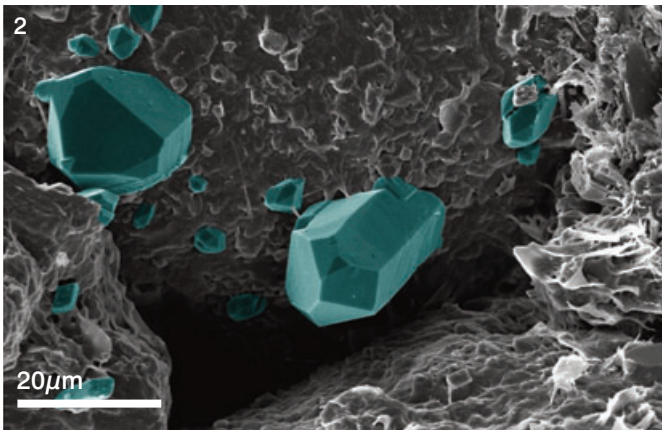
ISAAC
Imaging Spectroscopy And Analysis Centre

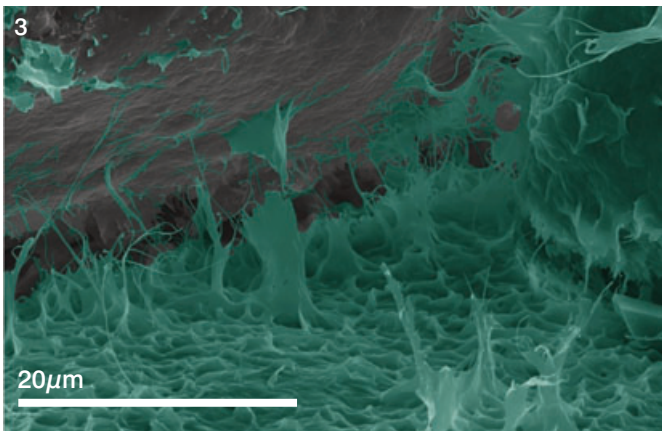
Mineral Characterisation of Subsurface Sandstone Reservoir Clays

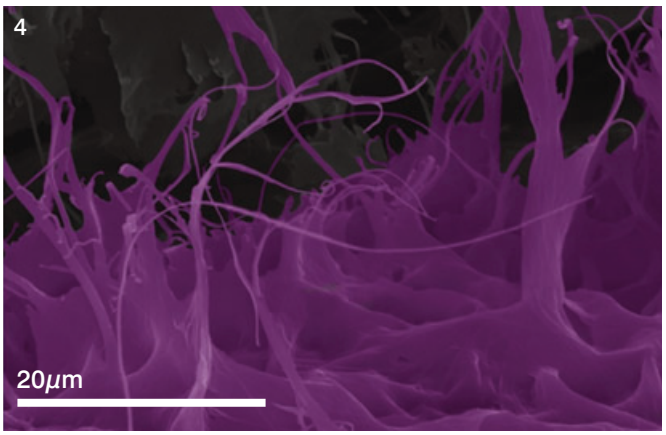
Reservoir Storage and Transmission of Valuable Resources

Sandstone reservoirs play a vital role in the storage and transmission of valuable resources, such as drinking water, crude oil, and natural gas. Porosity and permeability are two key properties that together affect whether sandstones can store and transmit commercially usable quantities of these fluids. Clay minerals are often the primary component of sandstones that impact porosity and permeability. Thus, the capability to determine the physical and chemical characteristics of clay minerals in sandstones, and then to understand the economic ramifications for developing aquifers or reservoirs, are of critical importance to the water and hydrocarbon industries.









Clay Minerals Pose a Difficult Customer Challenge

Many factors interact to influence the petro-physical properties of sandstones, but the types of clay minerals that fill pore spaces, together with their abundance and crystal size, are particularly significant. For example, coarsely crystalline clays, such as kaolinite, may fill up pore spaces, whereas fine fibrous clays, such as illite, can grow between pores and greatly reduce permeability. The very fine crystal size and complex mineralogy of clays combine to make them notoriously difficult to identify and to characterise using standard petrographic techniques, such as transmitted light microscopy. Without an in-depth understanding of clays and their properties, it can be hard to assess why a hydrocarbon or water well is producing poorly and, therefore, to determine what remedial actions might be taken.

Imaging and Analysing Clays with Electron Microscopy

Scanning electron microscopy (SEM) is the best tool for evaluating those aspects that limit the porosity and permeability of sandstones. The two SEM's in the Imaging Spectroscopy and Analysis Centre (ISAAC) in the School of Geographical and Earth Sciences (GES) at the University of Glasgow are ideal for this task. Both have field-emission guns that can operate in low vacuum to produce very high resolution images. One SEM can operate in 'environmental' mode, thus allowing accurate analysis of sandstones and their clays as they would exist in groundwater aquifers or hydrocarbon reservoirs.

In imaging mode, ISAAC's SEM's can characterise and often identify the positions of clays within pore spaces from their crystal shapes. Then once the chemical composition is determined by X-ray analysis, the SEM's can also pick out individual clay mineral crystals.

As well as clays, other minerals may grow as cements to fill pore spaces in sandstones, including quartz and calcite. Again, these minerals may be important porosity destroyers, but are difficult to identify in a two-dimensional thin section. SEM analysis reveals the sizes and shapes of the cement crystals with great clarity, and specialised software, attached to the microscopes, enables true three-dimensional imaging of the pore spaces and cements.

GES and ISAAC Expertise Provides Solutions for Reservoir Characterisation

ISAAC's state-of-the-art facilities, combined with the expertise and knowledge of GES, enable the University of Glasgow to offer comprehensive characterisation and analysis of sandstone porosity and permeability, even in conditions similar to those found in deep subsurfaces, which can guide a customer's technical and commercial decision-making concerning groundwater aquifers and hydrocarbon reservoirs. Rapid turnaround of analysis can also be provided to satisfy urgent client requirements.

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Images

1. *Calcite cement crystal filling sandstone pore space*
2. *Quartz cements projecting from quartz grain into pore space*
3. *Pore spaces within sandstone, whose floor is lined by 'crinkly' smectite with illite fibres growing across throat*
4. *Throat between pore spaces in sandstone completely blocked by illite fibres*