Petroleum engineering: Hydraulic fracturing

CSIRO has extensive expertise in hydraulic fracturing and is developing new applications of hydraulic fracturing and methods of analysis for the petroleum, mining and geothermal industries, and for geoscience research.

Hydraulic fracturing is a powerful technology used to stimulate reservoirs and, as applied in mining, to modify rock mass strength. CSIRO's hydraulic fracturing team is developing new understanding of hydraulic fracture mechanics using an integrated approach based on theoretical development, experimental investigation and application of results, in partnership with industry.

Expertise

The hydraulic fracturing team is focussed on complete integration of theoretical development, laboratory and field experimentation, and application, to deliver fundamentally sound innovations and improvements with a direct path to impact.

By using theory to guide experimentation, and then experimentation to guide theory, the team has developed a strong track record in advancing and finding new applications for this technology.

Facilities

LABORATORIES

The hydraulic fracturing laboratory has capabilities to measure fracture growth and geometry (including full-field fracture width) in rock and rock analogue materials under controlled stress and stress gradient conditions. Rock sample preparation and characterisation capability is also available.

Facilities include a field fracturing laboratory with equipment that can be used in the field to carry out and monitor full-size hydraulic fracture treatments.

In the field, treatments with and without proppant can be conducted, using water, linear gel and cross-linked gel fluids. Monitoring can also be performed using microseismic and tiltmeter arrays. Piezometer, extensometer and borehole scanning data can also be collected and analysed.

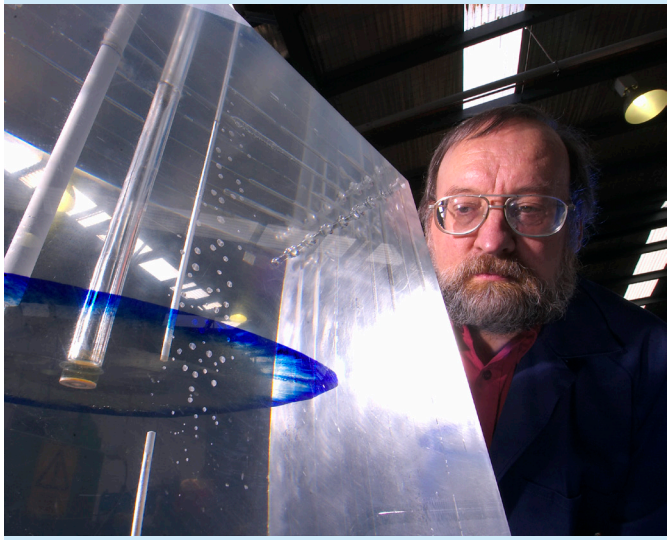
ANALYSIS AND MODELLING

The team's analysis capability is based on scaling methods and analysis of the asymptotic regimes of hydraulic fracture behaviour. These methods provide rigorous tools that can be used to simplify relationships and generate non-dimensional reduced parameter spaces, providing guidance for our numerical studies and laboratory experimental designs.

We have a strong grounding in engineering mechanics and use a range of solid and fluid mechanics analysis packages, as well as developing specialised models for our research.

Case studies

- A numerical study, designed using scaling methods, resulted in the development of a theory and methods to design hydraulic fracture treatments when multiple fractures are to be placed along the wellbore (ie. shale gas wells). The method has been verified using published data and geometry data from mine through mapping projects and laboratory experiments (see photo).



Hydraulic fracturing experiments in transparent materials enable full-field fracture width measurement using a novel CSIRO-developed method.

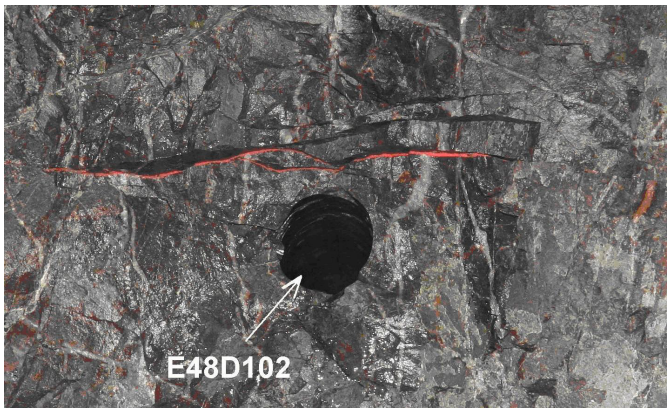
- The team introduced hydraulic fracturing, for the purpose of cave inducement and pre-conditioning, to the mining industry and continues to develop methods and equipment for this application. This new method is currently being applied to ore bodies at a number of mines in Australia and overseas.
- The team has carried out experimental programs in coal and hard rock that have included physical mining and mapping of the created hydraulic fracture geometry. The mapped fracture data was used to study how hydraulic fractures grow through rock, including how they interact with, and cross, natural fractures. The mapped fracture geometry was compared to the geometry inferred by indirect remote methods or by analysis of treatment parameters.

Our research scientists partner with highly qualified and experienced technicians for the design, fabrication, operation and maintenance of specialised laboratory and field equipment and instrumentation.

Applying the capability

The hydraulic fracturing team works closely with industry, either through direct contract with a single client or by forming and operating a consortium project.

For example, a series of laboratory experimental measurements of hydraulic fracture growth through stress barriers has been completed for an industry client. The data from these experiments have been used to evaluate the effectiveness of the client's three-dimensional hydraulic fracture model.



A hydraulic fracture mapped after mining. A red plastic particulate was injected into the fracture for visibility.

Our collaborators

The group collaborates with a range of industry partners who provide funding and, in many cases, access to field sites and in-kind support.

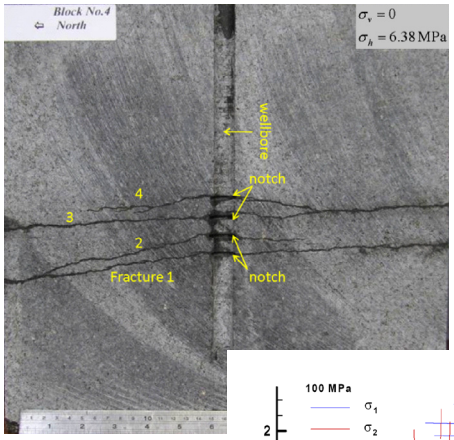
The team is developing a new generation of models for application to coal fracturing. An initial version of a T-shaped hydraulic fracture model has been developed, which is a geometry often formed in stimulation of coal.

The team has a long established and continuing collaboration with the University of Minnesota that includes extended visits by research staff and PhD students, and joint research projects.

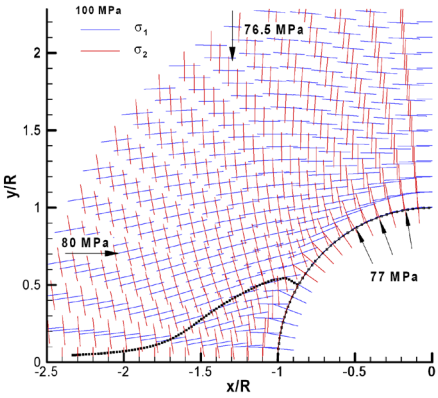
Getting involved

The hydraulic fracturing team works directly with industry to address specific issues. Some issues that require larger efforts are addressed by forming a consortium of companies.

We can also develop, test and supply specialised equipment for application of hydraulic fracturing to pre-conditioning and to stimulation of in-seam coal gas drainage holes.



Rock cross-sectioned after a number of closely spaced hydraulic fractures were placed.



Numerical calculation of the path followed by a hydraulic fracture growing from a wellbore.

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