Science Media Center

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expert reaction to study on using co2 as a fracking fluid

Research published in *Joule* demonstrates that using carbon dioxide as an alternative to water for fracking may bring multiple benefits.

Dr Nick Riley, Director, Carboniferous Ltd, said:

"This paper is an impressive and careful study. Using CO2 as a working fluid in oil and gas production not only provides revenue to offset the cost of CO2 capture through improving oil and gas production, but also geologically sequesters some of the injected CO2 by trapping it in the subsurface through a variety of physical and chemical processes. Traditionally, enhanced oil recovery using CO2 has been achieved by using alternating injections of water and Co2 gas, known as "WAG". The Weyburn oil field in Saskatchewan, Canada, has been a focus for studying CO2 sequestration in an EOR (enhanced oil recovery) for over 2 decades now.

"This new paper focusses on the possibility of using CO2 as a working fluid, without the use of hydraulic fracturing. It compares and contrasts how fracture development differs between CO2 fracturing and hydraulic fracturing, demonstrating that CO2 favours shear fracturing and avoids problems such as swelling clay reactions that can clog fractures and permeability when hydraulic fracturing is used. This paper acknowledges that there is still much to learn about the potential benefits for using CO2 instead of water in enhancing oil and gas production, especially at field scale and the operational challenges that might emerge. However, the study provides an excellent step forward in understanding some of the fundamental processes regarding supercritcal CO2 injection as a working fluid in oil and gas recovery, compared to using water."

Dr Hannah Chalmers, Senior Lecturer, University of Edinburgh, said:

"CO2 fracking might ultimately have environmental benefits compared to fracking with water, but this study does not include the analysis that is needed to establish whether CO2 fracking is likely to lead to an overall reduction in global greenhouse gas emissions.

"To achieve the level of CO2 emissions reduction that climate scientists suggest we need, it will become essential that any production and use of fossil fuels is only allowed if the produced CO2 can be captured and stored. If CO2 fracking increases the amount of fossil fuel that is available for use, it will also be necessary to capture and store the additional CO2 that is produced by this fossil fuel.

"It is important that further work is carried out to fully establish the fate of CO2 used in fracking operations. Any projects that are intending to store CO2 in the longer term should be characterised, carefully managed and monitored in the same way as any site being developed with the intention of keeping CO2 out of the atmosphere for thousands of years.

"It is also important that using CO2 for fracking is not confused with 'normal' CO2 storage projects. Although there are some similarities, CO_2 injection will be managed differently in CO_2 storage projects. In CO_2 storage projects, operators will manage operations so that it is expected that CO_2 will remain trapped in the rocks it is injected into for thousands of years. This will typically include ensuring that there are layers of rock that do not crack and instead contribute to keeping the CO_2 deep underground for these long periods of time."

Prof Geoffrey Maitland, Professor of Energy Engineering, Imperial College London, said:

"I think this research published in *Joule* is very interesting and provides good insight into one part of the jigsaw about whether CO_2 can be a viable alternative as a fracturing fluid to water.

"The use of supercritical CO_2 as a fracturing fluid, particularly in the recovery of shale gas or tight gas/oil, has been suggested by several groups across the world (US, UK, Australia, China) as an alternative to traditional water-based fluids over which it has several potential advantages. There has been some indication that supercritical CO_2 (CO_2 at temperatures and pressures where it has the density of a liquid but flows very easily like a gas) could be very effective at producing fractures and this research seems to confirm this, in the laboratory at least, whilst giving good insights into the different fracture mechanisms and geometries that may underpin such enhancements compared to water. The very high volumes of fluid required for fracturing (often 40,000 gallons) make the use of water particularly challenging in regions of water shortage, whereas in some regions CO_2 is naturally co-produced from oil and gas wells and readily available at reasonable cost. Also, the anticipated large growth in Carbon Capture and Storage (CCS) technology across the world, in order to meet the challenging Paris Agreement CO_2 reduction targets to avoid catastrophic climate change in a world where fossil fuels will continue to be used for many decades, could well produce a glut of affordable CO_2 that could be put to useful purposes before being stored underground. In fact, CO_2 sticks to shale rock more effectively than the in situ methane gas, so the combination of fracturing to remove methane from exposed rock surface with CO_2 wanting to displace the methane and sit on the surface itself, give the potential for much enhanced production of methane gas from shales whilst at the same time storing much of the injected CO_2 on the large area of shale surfaces created by the fracturing process – combining CO_2 fracturing and storage alongside enhanced methane production.

"This work indicates that the enhanced fracturing credentials of CO_2 look promising, not only in the laboratory but also by using it to produce oil from a low permeability ('tight') field reservoir where water fracturing was ineffective. The suggestion is that the complexity and effectiveness of the CO_2-induced fractures is due to the ease with which it flows into the rock (measured as a low viscosity) and hence the high leak-off rate of the supercritical CO_2 into the low permeability rock. The CO_2 is injected as a liquid in the field trial at low temperatures and the reservoir conditions are not given, so it is not clear what state the CO_2 is in during the fracturing process – one of the challenges of making this process work is to understand the differences in performance of CO_2 as a gas, liquid or supercritical fluid and to be able to control its optimum behaviour in the reservoir. Another challenge pointed out by the authors is that to carry sand particles (called 'proppant') to keep the fractures open for production, the CO_2 needs to be viscosified (made thicker like shower gel). This can be done using, for example, fluorinated polymers or surfactants, as used in the field test. However, these are expensive chemicals and even at small concentrations will result in large fluid costs given the vast volumes required to fracture a reservoir, with the risk of making the process economically unviable. A cheaper route to make liquid or supercritical CO_2 thicker is almost certainly needed. Besides, the effectiveness of CO_2 as a fracturing fluid seems related to its ease of flow (low viscosity) so a compromise needs to be struck between this and its ability to transport sand deep into fractures. The field test does show that slightly thickened CO_2 does produce oil from a tight reservoir where water fracturing is unsuccessful, but more work needs to be done to show whether there is a practical viscosity window that combines high fracturing efficiency with adequate proppant transport.

"So, this paper helps fill in one piece of the jigsaw on CO_2's fracturing capabilities and gives some encouragement that it might be a viable alternative to water, but this and many other pieces of the jigsaw need much further investigation before a technically and economically viable field-scale process can be developed. At Imperial we are investigating another piece of the jigsaw, the competitive sticking of CO_2 and methane on shales; this complements the very useful fracturing study of this research reported in *Joule*."

'Fracturing with Carbon Dioxide: From Microscopic Mechanism to Reservoir Application' by Song *et al.* was published in *Joule* at 16:00 UK time on Thursday 30th May.

Declared interests

Dr Nick Riley: "I currently assist companies exploring for shale gas, through my company Carboniferous Limited. In a non-commercial role I am an honorary research associate with the British Geological Survey supporting some of their academic research into shale gas. In recent years I have been a scientific advisory board member to the now completed CATO (Netherlands) & SUCCESS (Norway) geological CO_2 sequestration projects."

Prof Geoffrey Maitland: "I co-supervise a PhD student working on using CO_2 to displace methane from gas shales, sponsored by CSIRO, Australia. This process could be enhanced by the fracturing studied in this paper."