Unconventional Reservoirs for Carbon Sequestration

July 2023 | David Brown, Explorer Correspondent

At first thought, unconventional reservoirs don't seem like a great choice for carbon capture, utilization and storage. So why was CCUS a hot topic at the Unconventional Resources Technology Conference in June?

Maybe that first thought is all wrong.

Researchers have started to evaluate unconventional reservoirs for carbon sequestration, and they're finding a viable alternative to more conventional choices.

"Think about it this way: Unconventional (reservoirs) can produce despite low porosity and permeability. How can it produce? Because it has a big matrix and fracture interface," on a million-square-meters scale, said Sheng Peng, research scientist for the Bureau of Economic Geology at the University of Texas at Austin.

Sheng Peng

Peng and several of his fellow BEG researchers developed the URTeC presentation, “Feasibility of CO2 Storage in Depleted Unconventional Oil and Gas Reservoirs: Capacity, microscale mechanism, injectivity, fault stability and monitoring.”

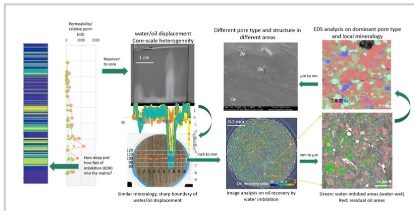
They estimate a sequestration capacity in developed unconventional reservoirs at 18-30 gigatonnes of CO2. That capacity will increase with ongoing production, as more pressure is released in more wells, Peng noted.

“We use a pressure-balance method. We get lower than previously reported yet significant capacity for unconventional based on our estimation, which is a new type of estimation of capacity, different from a volume-based method,” Peng said.

“It can contribute a lot. It can be a good addition to conventional reservoirs,” he added.

Chris Clarkson moderated the URTeC special session “Potential for Geologic Sequestration of CO2 in Deep, Low-Permeability Coal Seams.” He’s a professor of geoscience at the University of Calgary and director of its Tight Oil Consortium and Unconventional Reservoirs of Western Canada group.

Why Deep Coal Seams?



Why in the world would deep coal seams and other unconventional reservoirs, with low to sometimes ultra-low permeability and porosity, be considered candidates for CCUS?

“I would reply to this by asking, ‘Why in the world would you not consider it?’ We have the technology to inject massive amounts of CO2 through multi-fractured horizontal wells completed in shales and tight rock. This could be evaluated particularly for depleted fields,” Clarkson said.

“Once it is injected, CO2 storage is relatively secure because of ultra-low permeability, adsorption, etc. Remember, many of the shales being exploited with MFHWs are source rocks with essentially caprock-like reservoir properties, rocks ideal for sealing in fluids,” he observed.

Peng also cited the ability to use existing wells as a major plus for future CO2 injection. About 75 percent of newly deployed U.S. oil rigs in 2020 had horizontal/unconventional targets, he said.

“It’s a big up-front cost benefit. The accompanying data of geology, petrophysics , stimulation and production is invaluable, too. It’s not from scratch. We know the reservoir,” Peng noted.

The BEG project proposes using a huff-‘n’-huff – as opposed to huff-‘n’-puff – concept of discontinuous CO_2 injection, with injection followed by shut-in, then injection again. Peng said the shut-in period allows the injection pressure to disperse, making the subsequent injection easier and more efficient.

Chris Clarkson

“We only need a small amount of CO_2 to inject at a certain time, so we do not require an extensive CO_2 pipeline system, which is very expensive,” Peng noted, adding that the scale can be compatible with CO_2 air-capture technology.

Clarkson identified three major reasons why deep, unmineable coal seams are an attractive option for geological sequestration of CO_2:

- Relative security of CO_2 storage

“The primary gas storage mechanism in coal is gas adsorption, where gas adheres to the internal surface area of the coal-matrix organic matter, in a near liquid-like – high density – state, meaning a lot of gas can be stored in coal at low pressures,” Clarkson said.

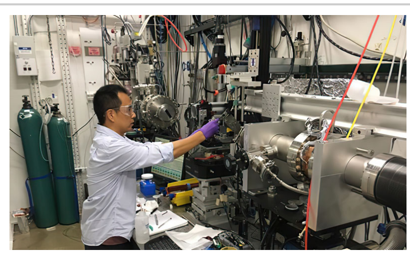
Once the gas is adsorbed, “its mobility is more limited than if it were in the free-gas or compressed gas state, which is more common for conventional gas storage reservoirs. CO_2 is more strongly adsorbed onto coal than native natural gas components, which means that CO_2 will displace natural gas when injected into coal,” he added.

- Global distribution of coal resources

Clarkson said substantial deep-coal resources exist in North and South America, Europe, Asia, South Africa and Australia, and CO_2 storage in deep coal is currently being evaluated in both Australia and China.

- Application of proven technologies

“Many drilling and completion technologies, including horizontal wells and even multi-lateral wells, have been successfully applied to natural gas extraction from coal. These same technologies can be used for CO_2 injection into coal, although until now, vertical wells have been used as injectors for field trials in North America,” Clarkson noted.



Sheng Peng in the BEG’s Unconventional Petrophysics Lab at the University of Texas at Austin

Challenges and Questions

Research into CO_2 sequestration in unconventional reservoirs is at an early stage. Challenges and problems to be studied and addressed include injectivity, leakage, formation response and long-term monitoring.

"I'm trying to understand how CO_2 can be injected and how it can be miscible with oil with the existence of water in the nanoporous system that has complicated structure and surface properties. The challenge for the specific problem is understanding the matrix and the matrix-fluid interaction. We need to understand how the geology will control the flow," Peng said.

"We have been talking about CCUS for 20-plus years, so those challenges are not only in technology," he noted.

"Making maximal use of the capacity, overcoming the negative impact of reservoir heterogeneity on injection, is another big challenge. Specific study on the rock and fluid, from micro-scale up to well-pad scale, and the optimal design of the injection mode through integrated laboratory and modeling works, are critical to address this problem," he said.

Clarkson said a possible negative associated with the use of deep coal seams for sequestration is loss of coal permeability caused by swelling induced by CO_2 adsorption.

"It is well known that the coal matrix will swell when exposed to an adsorbing gas, and this swelling can lead to a closure of natural fractures, the primary permeability pathway in coal, leading to a loss in coal permeability near a CO_2 injection well," he said.

"Counteracting this effect is the mechanical dilation of fractures when gas is injected into coal. In other words, CO_2 injection can 'balloon' fractures leading to an increase in permeability near the injection well," he noted.

Which effect dominates during CO_2 injection into coal is a complex function of geomechanical properties, fracture properties, adsorption characteristics and injection operations, Clarkson explained.

He cited a pilot project in the deep Mannville coals of Western Canada where injectivity increased with the CO_2 injection rate, and an injection test performed in pressure-depleted coals in an active CBM producing area in the Fruitland coal of the San Juan Basin of New Mexico, where significant injectivity loss was attributed to CO_2 swelling.

Peng said "at the very beginning of our study we thought, 'Is the capacity enough?' And then, 'What about injectivity?' Now I think the bigger challenge is the containment of the CO_2. Leakage of CO_2 during the injection is another challenge. It needs to go into the matrix and not escape from the system, or at the wellhead."

"Monitoring unconventional (CO_2 sequestration) is very challenging, but will be essential," he observed.

The 2022 U.S. Inflation Reduction Act increased CCUS tax credits to up to $85 per tonne of CO_2 permanently stored, and $60 per tonne of CO_2 used for enhanced oil recovery or other industrial uses of CO_2, if emissions reductions can be clearly demonstrated.

"I think that's a good incentive for industry to have more interest and more motivation. It changes things," Peng said.

He thinks CO_2 injection for enhanced recovery, CO_2-EOR, "can be a vital part of the long-term strategy of CCUS in unconventional reservoirs. On one hand, CO_2-EOR can produce more oil – an economic benefit. On the other, it creates further capacity for storage," he noted.

"We're still in an early stage where we need to get industry involved, to attract interest. For them, a good start would be CO_2 for EOR," he said.

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Drilling site near Red Deer, Alberta for the pilot project injecting CO2 into the Mannville coals. Photo courtesy of the University of Calgary.

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CO2 sequestration is wrong.

FroM CO2COALITION.ORG Fact #6: CO2 Our current geologic period (Quaternary) has the lowest average CO2 levels in the last 600 million years. Contrary to the oft-repeated mantra that today's CO2 concentration is unprecedentedly high, our current geologic period, the Quaternary, has seen the lowest average levels of carbon dioxide since the Precambrian. Though CO2 concentrations briefly peaked 320,000 years ago at 300 ppm, the average for the past 800,000 years was 230 ppm (Luthi 2008). The average CO2 concentration in the preceding 600 million years was more than 2,600 ppm, nearly seven times our current amount and 2.5 times the worst case predicted by the IPCC for 2100. Our current geologic period (Quaternary) has the lowest average CO2 concentration in more than 600 million years. We don't have too much CO2 we don't have enough. CO2 sequestration is driven by the U.S. government. 45Q is a federal tax credit that incentivizes CO2 utilization, sequestration and removal. Currently, 45Q provides: • $35/ton for CO2 stored geologically through enhanced oil recovery; • $35/ton for other beneficial uses of CO2 such as converting carbon emissions into fuels, chemicals or useful products like concrete; or • $50/ton for CO2 stored in geological formations and not used in enhanced oil recovery.

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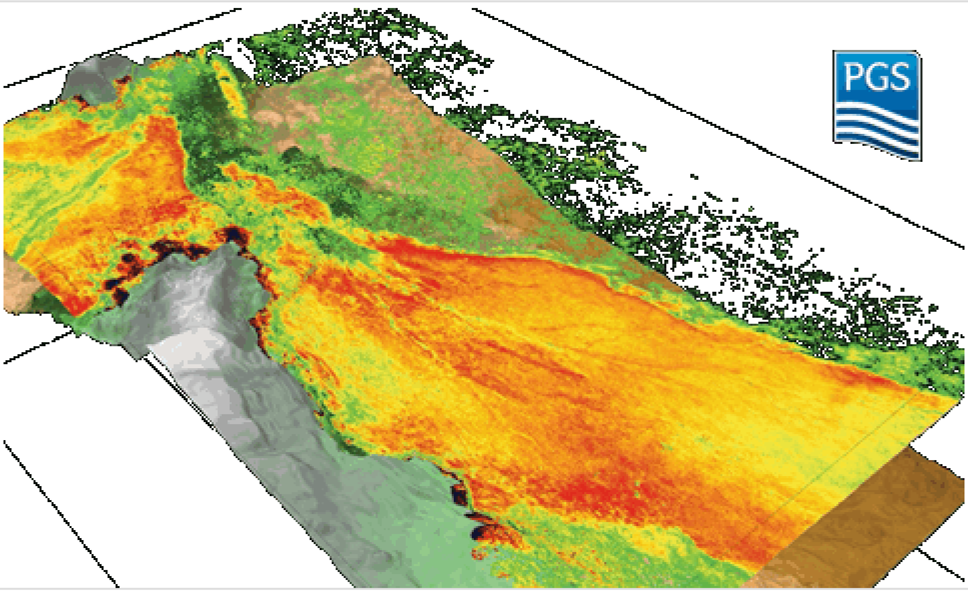

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