

# Better Carbon Storage with Stacked Geology

JULY 23, 2024

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The overarching goal of all carbon capture and storage projects is the same: Keep carbon dioxide (CO<sub>2</sub>) emissions out of the atmosphere by storing them in the subsurface for good.

One way to do that is to inject the CO<sub>2</sub> into a reservoir space that's covered with a big lid – an impermeable caprock that can keep the gas in place and stop any upward flow in its tracks. That's the model that petroleum exploration has relied on for decades when searching for oil traps, and it works for both oil and CO<sub>2</sub>. But according to research led by The University of Texas at Austin's Bureau of Economic Geology, subsurface reservoirs that are covered by a collection of hundreds of smaller lids – collectively called a “composite confining system” – may be the better option for keeping carbon trapped for the long term.

That's good news for the carbon storage industry. This type of distributed system is common in a range of geological environments, including the Texas Gulf Coast.

“Directly under what is the largest concentration of emissions in the U.S. we have incredible

reservoirs, but few regional seals.

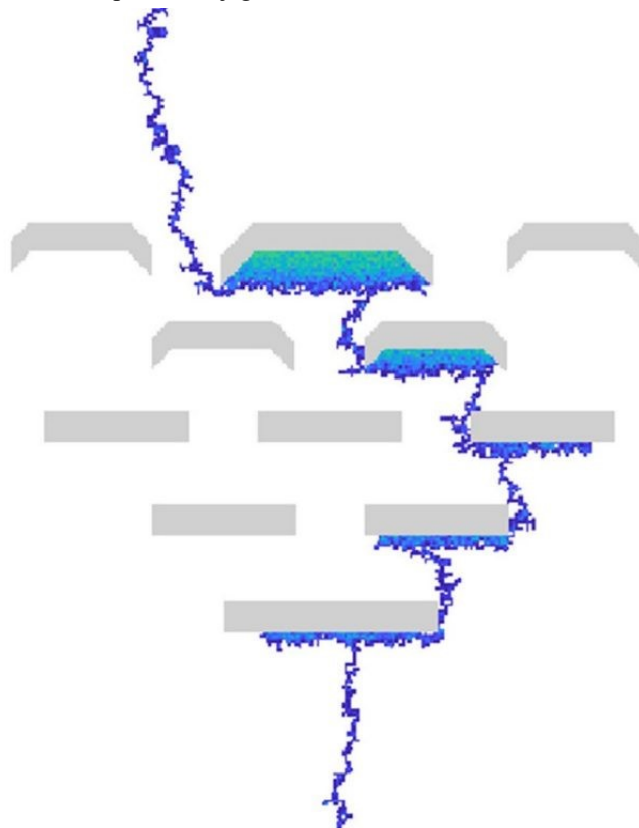
What we have instead, is lots and lots of discontinuous barriers to vertical flow,” said Alex Bump, a research associate professor at the Bureau’s Gulf Coast Carbon Center in the UT Jackson School of Geosciences.

“There is a very local motivation for this research but the application is global.”

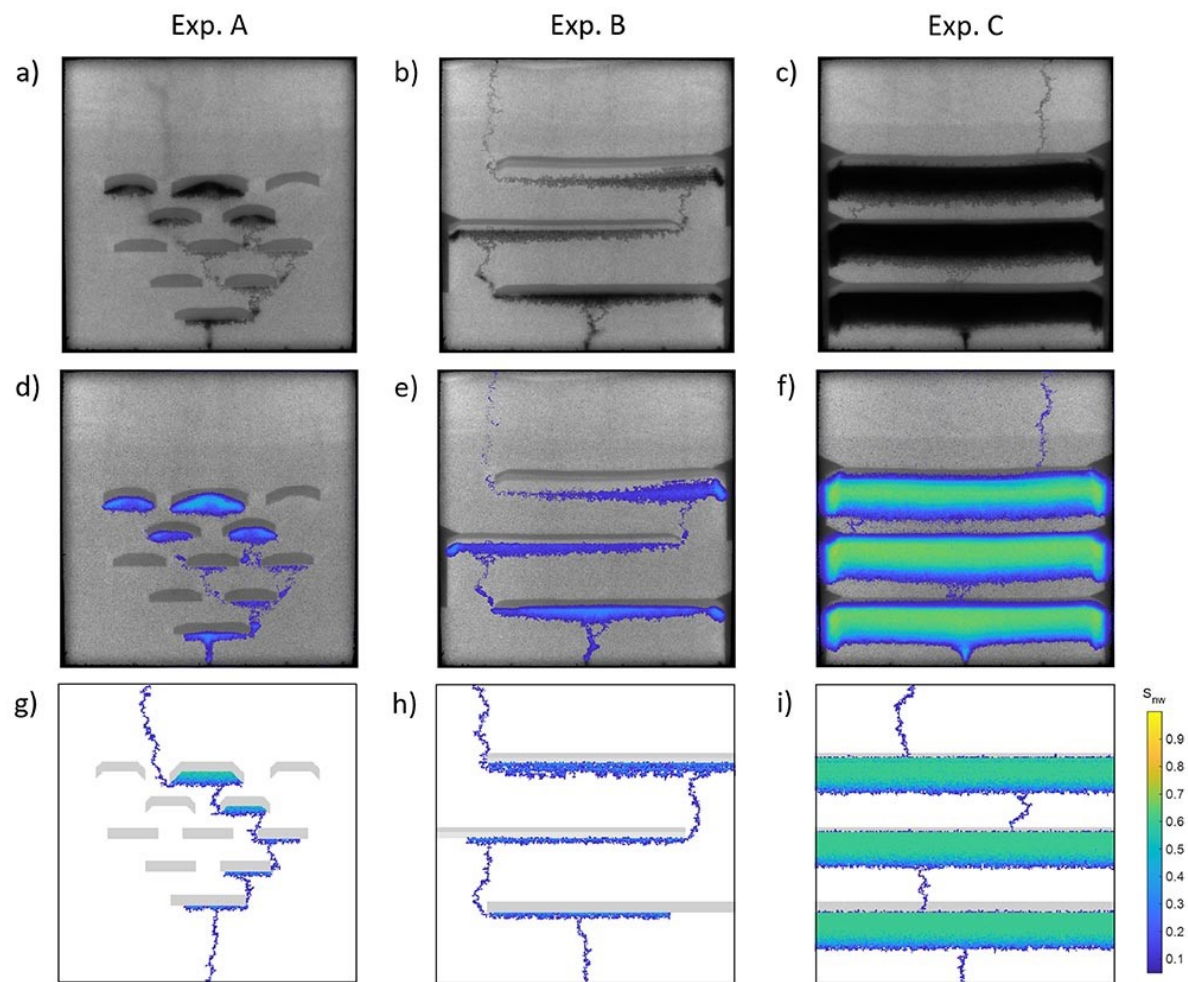
Many people working in carbon storage have roots in oil and gas – including Bump. The two industries share similar knowledge bases in reservoir geology and fluid dynamics. However, according to Bump, this has also led to some assumptions about optimal carbon storage scenarios – namely, that the same sort of caprock-sealed reservoirs that are proven oil traps should also be the preferred place to store carbon.

According to Bump, there are key differences between hydrocarbon production and carbon storage that suggest rethinking the inherited concepts.

“In petroleum, the goal of production favors large-volume, concentrated, mobile accumulations, so we explore for large traps, and high-permeability reservoirs with an impermeable seal,” said Bump.



A computer simulation of a composite reservoir tank experiment described in the study. The experiment is run until the fluid escapes from the confining system. The grey figures are barriers. The blue is a fluid plume meant to simulate carbon dioxide. The graphic is cropped from Figure 2 in the study. Credit: Hailun Ni, et al.



A figure showing the results of three experiments simulating the movement of a plume of carbon dioxide through various configurations of composite confining system. The experiments are run until the fluid escapes the system. The top row (a-c) shows camera images of tank experiments. The middle row (d-f) shows the saturation fields of the fluid at the end of the experiment. The bottom row (g-i) shows the results of a computer simulation of the experiment. The graphic is from figure 2 of the study. Credit: Hailun Ni, et al.

That same model works for carbon storage, but the factors that make it ideal for petroleum production make it risky for storage, Bump said. For example, if there is a leak in the seal (such as an improperly decommissioned well), then there is a large, concentrated volume of  $\text{CO}_2$  that can potentially leak out. In contrast, the multiple barriers of a composite confining systems not only help prevent escape but also help spread the  $\text{CO}_2$  plume across the available pore space in a reservoir. In doing so, they effectively immobilize the  $\text{CO}_2$ . Even where there might be an escape path, there is little or no mobile  $\text{CO}_2$  to feed it.

Bump compares the differences between a caprock and composite approach to catching a water leak with a bucket versus a pile of towels. Both can do the job. But there's no risk of the water spilling with the towels. The towels simply soak it up.

In a paper published in the *International Journal of Greenhouse Gas Control* (<https://www.sciencedirect.com/science/article/pii/S1750583624000689>), Bump and colleagues at the Gulf

Coast Carbon Center, Hailun Ni and Sahar Bakhshian, make the case for composite confining systems for CO<sub>2</sub> storage by presenting data from experimental models, numerical simulations and actual reservoirs. Their experiments and numerical models show that the length and frequency of the barriers are the two most influential factors when it comes to an effective confining system. They also found that the barriers don't have to be particularly substantial to be effective. Even minor reductions in grain size between geologic layers are enough to divert the path of a rising CO<sub>2</sub> plume – helping to spread the gas laterally throughout the reservoir, with little migration toward the surface.

Bump said that next on the agenda is to spread the word about composite confining systems for carbon storage. He is currently working on developing a best-practices guide for finding and permitting these types of reservoirs for CO<sub>2</sub> storage.

### Composite Confining Systems: Rethinking petroleum seals...



“This is really about creating a user’s manual,” Bump said. “We’re figuring out how to take a good idea and apply it. There are already commercial projects moving forward with this on the Gulf Coast. We want to make it a standard part of the global toolkit for carbon storage.”

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