

Study reveals how to improve natural gas production in shale

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A Los Alamos study reveals how production pressures can be optimized to efficiently recover natural gas. Credit: Los Alamos National Laboratory

A new hydrocarbon study contradicts conventional wisdom about how methane is trapped in rock, revealing a new strategy to more easily

access the valuable energy resource.

"The most challenging issue facing the shale energy industry is the very low hydrocarbon recovery rates: less than 10 percent for oil and 20 percent for gas. Our study yielded new insights into the fundamental mechanisms governing hydrocarbon transport within shale nanopores," said Hongwu Xu, an author from Los Alamos National Laboratory's Earth and Environmental Sciences Division. "The results will ultimately help develop better [pressure](#) management strategies for enhancing unconventional hydrocarbon recovery."

Most of U.S. [natural gas](#) is hidden deep within shale reservoirs. Low shale porosity and permeability make recovering natural gas in tight reservoirs challenging, especially in the late stage of well life. The pores are miniscule—typically less than five nanometers—and poorly understood. Understanding the [hydrocarbon](#) retention mechanisms deep underground is critical to increase [methane](#) recovering efficiency. Pressure management is a cheap and effective tool available to control production efficiency that can be readily adjusted during well operation—but the study's multi-institution research team discovered a trade-off.

This team, including the lead author, Chelsea Neil, also of Los Alamos, integrated [molecular dynamics simulations](#) with novel in situ [high-pressure](#) small-angle neutron scattering (SANS) to examine methane behavior in Marcellus shale in the Appalachian basin, the nation's largest natural gas field, to better understand gas transport and recovery as pressure is modified to extract the gas. The investigation focused on interactions between methane and the organic content (kerogen) in rock that stores a majority of hydrocarbons.

The study's findings indicate that while high pressures are beneficial for methane recovery from larger pores, dense gas is trapped in smaller,

common shale nanopores due to kerogen deformation. For the first time, they present experimental evidence that this deformation exists and proposed a methane-releasing pressure range that significantly impacts methane recovery. These insights help optimize strategies to boost natural gas production as well as better understand [fluid mechanics](#).

Methane behavior was compared during two pressure cycles with peak pressures of 3000 psi and 6000 psi, as it was previously believed that increasing pressure from injected fluids into fractures would increase gas recovery. The team discovered that unexpected methane behavior occurs in very small but prevalent nanopores in the kerogen: the pore uptake of methane was elastic up to the lower peak pressure, but became plastic and irreversible at 6,000 psi, trapping dense methane clusters that developed in the sub-2 nanometer pore, which encompass 90 percent of the measured [shale](#) porosity.

Led by Los Alamos, the multi-institution study was published in Nature's new *Communications Earth & Environment* journal this week. Partners include the New Mexico Consortium, University of Maryland, and the National Institute of Standards and Technology Center for Neutron Research.

More information: Chelsea W. Neil et al, Reduced methane recovery at high pressure due to methane trapping in shale nanopores, *Communications Earth & Environment* (2020). [DOI: 10.1038/s43247-020-00047-w](#)

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