RESERVOIR SOLUTIONS

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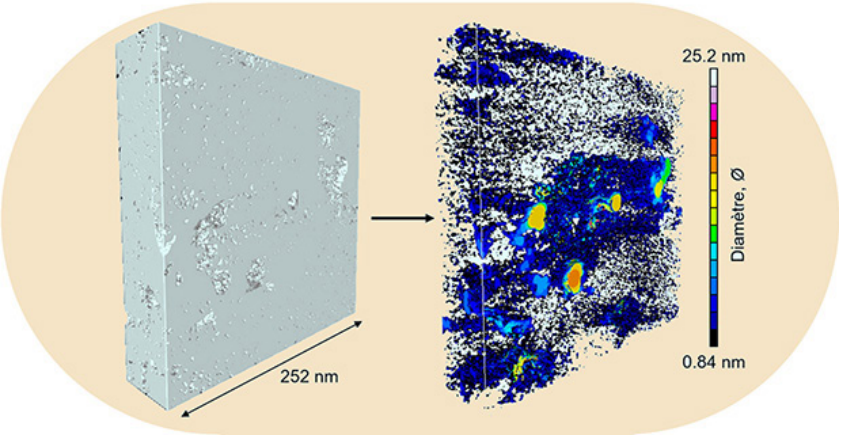
3D imaging of kerogen to improve production forecasts, MIT researchers say

"More accurate predictions of how much oil or gas can be recovered from any given formation" can be achieved through electron tomography of kerogen, said researchers at the Massachusetts Institute of Technology last October. They have used the imaging technique to generate 3D images of the nanostructure of pores in an organic component of oil and gas source rocks with 50 times more detail than previously achieved.

The 3D images have a resolution of less than 1 nanometer or one-billionth of a meter. Previous attempts to study kerogen structure had never imaged the material below 50-nanometers resolution, the researchers said.

The technical paper is posted on the website of the National Academy of Sciences at https://www.pnas.org/content/pnas/early-/2018/11/14/1808402115.full.pdf



Using electron tomography, Pellenq et al probed a kerogen sample to study its internal structure. At left, the sample as seen from the outside, and at right, the detailed 3D image of its internal pore structure. Image credit: MIT News Office.

The industry has long known that thermal maturity of kerogen is a key to its productivity and that pore structure and its interactions with fluids govern the mechanisms involved in hydrocarbon production from shale.

"Our 3D reconstructions confirm the formation of nanopores and reveal increasingly tortuous and connected pore networks in the process of thermal maturation," the study stated. "Relatively immature kerogen tends to have much larger pores but almost no connections among those pores, making it much harder to extract the fuel. Mature kerogen, by contrast, tends to have much tinier pores, but these are well-connected in a network that allows the gas or oil to flow easily, making much more of it recoverable."

In electron tomography, a small sample of the material is rotated within the microscope as a beam of electrons probes the structure to provide cross-sections at one

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angle after another. These are then combined to produce a full 3D reconstruction of the pore structure.

Sampling mature kerogen can be cost-effective. "Analysis can be done on rotary sidewall cores taken when drilling is stopped to acquire logs," said **George Dames**, advising senior vice president geoscience/geologist at Ryder Scott. "Geochemistry and TOC (total organic carbon) analysis is frequently done on cuttings."

Drill cuttings from a siliceous Marcellus formation in Pennsylvania provided the first kerogen sample tested by researchers. The less expensive cuttings process involves removing pieces of broken rock from the well via drilling fluids and raising them to the surface for study.

The paper was written by **Roland Pellenq**, MIT senior research scientist, as well as others at MIT, Shell Technology Center in Houston, and French National Center for Scientific Research and Aix-Marseille University in France.

Publisher's Statement

Reservoir Solutions newsletter is published quarterly by Ryder Scott Co. LP. Established in 1937, the reservoir evaluation consulting firm performs hundreds of oil and gas reserves studies a year. Ryder Scott multi-disciplinary studies incorporate geophysics, petrophysics, geology, petroleum engineering, reservoir simulation and economics. With 115 employees, including 80 engineers and geoscientists, Ryder Scott has the capability to complete the largest, most complex reservoir-evaluation projects in a timely manner.

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