

Novel method for investigating pore geometry in rocks

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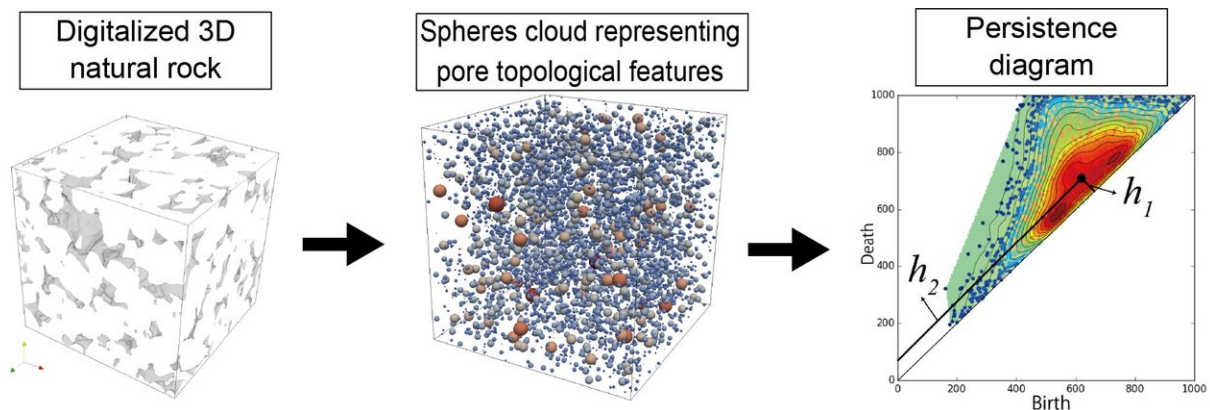


Figure: Left: This is a digitalized 3D natural rock, Center: Spheres cloud representing pore topological features, Right: Persistence diagram. Credit: International Institute for Carbon-Neutral Energy Research (I2CNER) / Institute of Mathematics for Industry (IMI), Kyushu University

Based on persistent homology theory, researchers from Japan's Kyushu University presented a new parameter and a new method for evaluating the heterogeneity of porosity

Fukuoka, Japan—Whether or not we realize it, mathematics permeates our lives in countless ways. Sometimes, the role of mathematics is difficult to grasp, but other times it's [rock](#) solid.

Although the mineral grains that form a rock are important, it is the pores—the empty spaces between those grains—that often carry vital resources such as oil, gas, and drinking water. The geometry of pores can strongly affect the storage, flow, and extraction of those resources. Thus, improving understanding of pore geometry is of great interest to many researchers and industry professionals.

In a fusion of mathematics and earth science, researchers from the International Institute for Carbon-Neutral Energy Research (I2CNER) and the Institute of Mathematics for Industry (IMI) of Kyushu University have now developed an innovative [method](#) to characterize pore geometry, based on a concept called persistent homology theory, as reported in a study published in *Water Resources Research*.

An important difference between natural rocks and artificial media is that the physical characteristics of rock tend to be relatively heterogeneous. This state-of-the-art method is particularly useful for characterizing that [heterogeneity](#) in pores.

The study's first author, Fei Jiang, explains, "In the proposed method, complex pore geometry is first transformed into sphere cloud data. Then, a [persistence](#) diagram is calculated from the point cloud. A new parameter, the distance index H as a metric, is derived from the persistence diagram, and is proposed to characterize the degree of rock heterogeneity."

A strong relationship was confirmed between heterogeneity and the distance index H . In addition, a new empirical equation using this metric H is proposed to predict the effective elastic modulus of rocks.

"To test the newly proposed method based on the [geometry](#) of real rocks, four types of rock with different pore structures, including two carbonates and two sandstones, were investigated," co-author Takeshi

Tsuji explains. "Persistence diagram analysis was more effective for quantitatively estimating the heterogeneity of relatively homogeneous sandstone compared with the conventional method. This new method was also superior in terms of distinguishing the different rock types."

Additional advantages of this method of analysis are that the persistence diagram is relatively stable with small changes in [pore](#) space, and the distance index H can be calculated very efficiently. Information extracted from persistence diagram analysis can be used to directly predict physical properties (such as permeability and elasticity) based on the microstructures of rocks. Thus, persistence diagram analysis may prove to be an important new tool for understanding the heterogeneity of pores in different rock types.

More information: Fei Jiang et al, Pore Geometry Characterization by Persistent Homology Theory, *Water Resources Research* (2018). [DOI: 10.1029/2017WR021864](#)

Provided by Kyushu University, I2CNER

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