Compaction bands — thin, highly compressed zones found in the Aztec Sandstone at Valley of Fire, Nevada, shown here, and in the Navajo Sandstone at the Kaibab monocline in Utah — were previously thought to be impermeable.



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new method for calculating permeability — a measure of how fast fluid flows through rock - has revealed that certain thin rock layers, called compaction bands, are orders of magnitude more permeable than previously thought, which could improve the management of oil and gas reservoirs and water aquifers.

"It was previously thought that compaction bands are almost impermeable compared to the outside host rock," says WaiChing Sun, a geotechnical engineer at Northwestern University and lead author of the new study in Geophysical Research Letters. "Our observations provide new evidence that this may not always be the case."

Previous models estimated the bands were hundreds to thousands of times less permeable than the surrounding sandstone, which would have presented a significant barrier to fluid flow. However, these models were produced using 2-D thin sections of compaction bands, which had been artificially reproduced in a lab, to estimate pore space geometry — the shape of the network of open space in between grains through which fluid could flow.

In the new research, Sun and his colleagues studied naturally formed bands in field samples of Aztec Sandstone from Nevada. The team took 3-D tomographic images, similar to a medical CAT scan, both inside and outside of the compaction bands. Once they had the 3-D geometric structure of the pore space, the team applied a numerical method that analyzes how well-connected the pore spaces are and whether they form a flow network. The calculations showed the Aztec compaction bands are only about 10 times less permeable

than the surrounding host rock, not thousands, as previously thought.

Calculating permeability is challenging because different-sized samples of the same rock formation can produce different measurements of permeability, depending on the porosity at the sample location. "It is important to look at permeability across different scales," Sun says, "because permeability is size-dependent."

While the numerical method more accurately scales up the pore-scale permeability to the specimen-scale, it is the next step — linking the pore-scale to the field-scale — that may someday allow geoscientists to accurately calculate the permeability of a reservoir from a handful of well-chosen samples.

If Sun's calculations are correct, using 3-D tomography to determine pore geometry and permeability will render improved predictions, says Youngseuk Keehm, who studies rock physics at Kongju National University in South Korea and developed one of the widely used 2-D methods for determining permeability.

However, 3-D tomography can be costly to do on a large scale, Keehm notes. That said, if Sun's method is streamlined and widely adopted by industry - whether that be the oil and gas industry or another field — Keehm says, the cost would likely come down.

Differences in permeability within a rock formation are important in applications such as oil drilling or hydraulic fracturing, which involve the injection or withdrawal of pore fluids. The new finding could also have applications in carbon sequestration, where the less permeable compaction bands could act as seals to trap carbon dioxide underground.

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