Going with the flow: Researchers find compaction bands in sandstone are permeable

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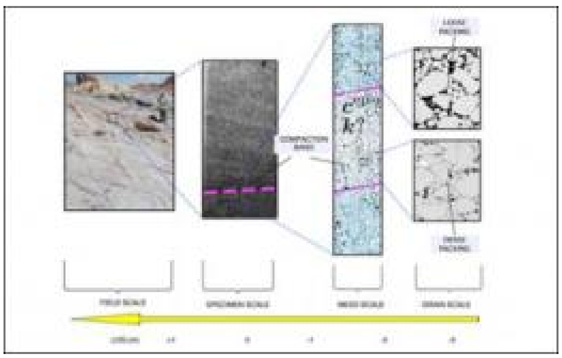
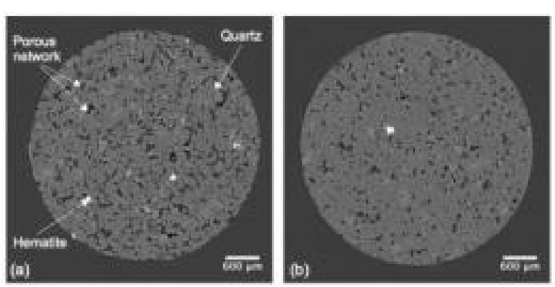


Compaction bands at multiple scales ranging from the field scale to the specimen scale to the meso and grain scale. At the field scale, picture shows the presence of narrow tabular structures within the host rock in the Valley of Fire. At the grain scale, images show clear differences in porosity (dark spots) density. This research aims at quantifying the impact of grain scale features in macroscopic physical properties that control behavior all the way to the field scale. Credit: José Andrade/Caltech

When geologists survey an area of land for the potential that gas or petroleum deposits could exist there, they must take into account the composition of rocks that lie below the surface. Take, for instance, sandstone—a sedimentary rock composed mostly of weakly cemented quartz grains. Previous research had suggested that compaction bands—highly compressed, narrow, flat layers within the sandstone—are much less permeable than the host rock and might act as barriers to the flow of oil or gas.

Now, researchers led by José Andrade, associate professor of civil and mechanical engineering at the California Institute of Technology (Caltech), have analyzed X-ray images of Aztec sandstone and revealed that compaction bands are actually more permeable than earlier models indicated. While they do appear to be less permeable than the surrounding host [rock](), they do not appear to block the flow of fluids. Their findings were reported in the May 17 issue of *Geophysical Research Letters*.

The study includes the first observations and calculations that show fluids have the ability to flow in sandstone that has compaction bands. Prior to this study, there had been inferences of how permeable these formations were, but those inferences were made from 2D images. This paper provides the first permeability calculations based on actual rock samples taken directly from the field in the Valley of Fire, Nevada. From the data they collected, the researchers concluded that these formations are not as impermeable as previously believed, and that therefore their ability to trap fluids—like oil, gas, and CO_2—should be measured based on 3D images taken from the field.



Cross-sectional slice of material showing pore-scale structure in Valley of Fire sandstone: A. Host rock. B. Inside compaction band. Darker spots represent voids, which are clearly more abundant in the host rock that inside the compaction band. Credit: José Andrade/Caltech

"These results are very important for the development of new technologies such as CO2 sequestration—removing CO2 from the atmosphere and depositing it in an underground reservoir—and hydraulic fracturing of rocks for natural gas extraction," says Andrade. "The quantitative connection between the microstructure of the rock and the rock's macroscopic properties, such as hydraulic conductivity, is crucial, as physical processes are controlled by pore-scale features in porous materials. This work is at the forefront of making this quantitative connection."

The research team connected the rocks' 3D micromechanical features—such as grain size distribution, which was obtained using microcomputed tomography images of the rocks to build a 3D model—with quantitative macroscopic flow properties in rocks from the field, which they measured on many different scales. Those measurements were the first ever to look at the three-dimensional ability of compaction bands to transmit fluid. The researchers say the combination of these advanced imaging technologies and multiscale computational models will lead to unprecedentedly accurate measurements of crucial physical properties, such as permeability, in rocks and similar materials.

Andrade says the team wants to expand these findings and techniques. "An immediate idea involves the coupling of solid deformation and chemistry," he says. "Accounting for the effect of pressures and their potential to exacerbate chemical reactions between fluids and the solid matrix in porous materials, such as compaction bands, remains a fundamental problem with multiple applications ranging from hydraulic fracturing for geothermal energy and natural gas extraction, to applications in biological tissue for modeling important processes such as osteoporosis. For instance, chemical reactions take place as part of the process utilized in fracturing rocks to enhance the extraction of natural gas."

More information: "Connecting microstructural attributes and permeability from 3D tomographic images of in situ shear-enhanced compaction bands using multiscale computations," *Geophysical Research Letters*.

Provided by California Institute of Technology

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