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Investigating the Permeability Evolution of Artificial Rock During Ductile and Brittle Deformation Under Pressurized Flow

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The drilling of geothermal energy, CO_2 sequestration, and wastewater injection all involve the pressurized flow of fluids through porous rock, which can cause deformation and fracture of the material. Despite the widespread use of these industrial methods, there is a lack of experimental data on the connection between the pore pressure rise, the deformation, and permeability changes in porous structures. In this study, we developed an artificial rock material that can be deformed and fractured at low pressurized flows. By controlling the porosity, permeability, and strength of the material during the sintering process, it is possible to mimic various types of rock. The artificial rock was designed to accommodate radial flow and deformation, allowing for deformation tracking by monitoring the flux and applied pressure to calculate the permeability changes under various effective stresses. The study shows that there is a transition from dilating fracture at low effective stresses, which increased the permeability, to ductile compaction at high effective stresses, which reduced the permeability. The increased permeability due to the fracture led to hysteresis of permeability at low pressures that disappeared at high pressure due to the ductile compaction. This transition was shown to change with permeability and tensile strength and was phenomenologically captured by two models that were adjusted to this scenario.

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References

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