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Digital material laboratory: Considerations on high-porous volcanic rock

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Digital material methodology combines modern microscopic imaging with advanced numerical simulations of the physical properties of materials. One goal is to complement physical laboratory investigations for a deeper understanding of relevant physical processes. Large-scale numerical modeling of elastic wave propagation directly from the microstructure of the porous material is integral to this technology. The parallelized finite-difference-based Stokes solver is suitable for the calculation of effective hydraulic parameters for low and high porous materials.

Reticulite is formed in very high Hawaiian fire fountaining events. Hawaiian fire fountaining eruptions produce columns or fountains of lava, which can last for a few hours to days. Reticulite was originally thought to have formed from further expanded hot scoria foam. However, some researchers believe reticulite forms from magma that formed vesicles instantly, which expanded rapidly and uniformly to produce the polyhedral vesicle walls. These walls then ruptured and cooled rapidly.

The (open) honeycomb network of bubbles is held together by glassy threads and forms a structure with a porosity higher than 80%. The fragile rock sample is difficult to characterize with classical experimental methods and we show how to determine porosity, effective elastic properties and Darcy permeability by using digital material methodology. A technical challenge will be to image with the CT technique the thin skin between the glassy threads visible on the microscopy image. A numerical challenge will be determination of effective material properties and viscous fluid effects on wave propagation in such a high porous material.