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From Elastic Wave Velocities Evolution to Permeability: Prediction: Experiment and Modelling

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Theoretically, crack damage can result in a decrease of elastic wave velocities and in the development of anisotropy. Using non-interactive crack effective medium theory as a fundamental tool (Kachanov 1994), it is possible to calculate dry and wet elastic properties of cracked and porous rocks in terms of a crack density tensor, average crack aspect ratio and mean crack fabric orientation using the solid grains and fluid elastic properties. This result points out that from "well constrained" laboratory data obtained on cracked and porous rocks , it is possible to extrapolate crack density, anisotropy and saturation using wave velocity inversion as a tool.We will show examples of such inversion for several rock types (basalt, granite, marble and sandstones) in wet conditions.

Above the percolation threshold, macroscopic fluid flow also depends on the porosity, crack density, orientation and aspect ratio. Using the permeability model of Guéguen and Dienes (1989) and the crack density and aspect ratio recovered from elastic wave velocity inversion, we show how to successfully predict the evolution of permeability with pressure for direct comparison with laboratory measurements performed on the same rock types (basalt, sandstones, granite).

These combined experimental and modelling results illustrate the importance of understanding the details of how rock microstructures can change in response to an external stimulus in predicting the simultaneous evolution of rock physical properties.