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Determining hydraulic properties of rocks and understanding their relation to microstructure by different oscillatory hydraulic tests

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A rock is characterized by two hydraulic properties, the ease with which fluids can flow through it and the ability to store liquids. Fluid which is injected into a saturated rock is partly transported through the connected pore space following the prevailing pore-pressure gradient. Part of the fluid is stored because of its compressibility and that of the pore space. Thus, to describe the complete hydraulic behavior of a material, it is necessary to determine the transport property, e.g., permeability, as well as the storage property, e.g., specific storage capacity.

Hydraulic characteristics have been determined in laboratory tests for more than 50 years. Since the development of the oscillatory methods, it is possible to determine permeability and storage capacity reliably in a single experiment. In addition to the previously presented axial pore-pressure and pore-flow methods, a radial oscillatory pore-flow method is here used in laboratory experiments for the first time. The studied rock types, Wilkeson sandstone and Westerly granite, have differently structured pore spaces and exhibit different sensitivities to changes in effective pressure. The validity of the results was assessed by comparison with results from Darcy tests and physical limits.

The hydraulic properties, determined with the three oscillatory methods, differ significantly partly in a qualitative (pressure and period dependence) but mainly in a quantitative (different absolute values and variability) way. We argue that information about the structure of the pore space can be obtained by combining the different oscillatory methods and varying the oscillation period. Penetration depth depends on the selection of period. Furthermore, the three methods examine different parts of a heterogeneous pore space. With the different oscillatory methods, a portfolio of methods for the determination of hydraulic properties in laboratory tests is now available whose employment in combination with systematic variations of the oscillation period provides an exceptional potential for improving the understanding of the relation between microstructure and hydraulic properties.