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Permeability and seismic properties of thermally cracked and fluid saturated soda-lime-silica glass

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It is well established that the presence of compliant thin cracks strongly affects fluid-flow and seismic properties of rocks. Therefore, an improved understanding of the pressure-sensitive microstructure and related flow properties of cracked media, underpins significant progress in the study of frequency dependent seismic properties of rocks resulting from stress induced fluid flow. Populations of thin cracks of uniformly low aspect ratio were introduced into cylindrical specimens of soda-lime-silica glass by dropping oriented specimens, pre-heated to 500°C, into water. The resulting materials, with simple crack microstructures, are being assessed for their in-situ permeability by the transient flow method and their response in low-frequency forced-oscillation, under conditions of independent control of confining and pore pressures. Previous work in our laboratory has raised the possibility that measured permeabilities may be affected by fluid flow between specimen and the enclosing annealed copper jacket. Such bypass flow, responsible for an apparent permeability of $1.44 \times 10^{-20}\mathrm{m}^2$ at a differential pressure P_d of 66 MPa, has been observed with an intact glass specimen and argon pore fluid. It is concluded that bypass flow may therefore significantly affect the permeabilities measured on the cracked material (e.g. $4.78 \times 10^{-20}\mathrm{m}^2$ at P_d = 51MPa). These preliminary observations suggest that bypass flow between the specimen and the copper jacket, may result in a pressure-dependent threshold permeability of order $10^{-20}\mathrm{m}^2$ below which accurate measurements of permeability are precluded. Cracked soda-lime-silica glass specimens previously tested in our laboratory have proved impermeable to water - perhaps as a result of chemical interactions between the polar water molecule and the siliceous surfaces of narrow cracks. Accordingly, the cracked glass material has been tested successively with argon, pentane and water, as pore fluid. In contrast, the same specimen proved impermeable to water as pore fluid. Pentane is a non-polar fluid, broadly comparable with water in compressibility and viscosity. Accordingly, our preliminary result increases the likelihood that chemical properties of the pore fluid may control fluid flow through glass media – a subject of ongoing investigation. Finally, a vertical rather than horizontal orientation of the heated glass cylinder as it is quenched into water, has been tested in order to access a more nearly cylindrical symmetry of the thermal stress field. In this way, previous issues with poor alignment within the pressure vessel of a specimen slightly bent as the result of heterogeneity in crack distribution have been circumvented. The improved alignment newly allows both flexural and torsional oscillation measurements providing an assessment in progress on the persistence of saturated-isolated conditions down to mHz frequencies.