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Poroelastic relaxation in thermally cracked and fluid-saturated glass

Abdulwaheed Ògúnsàmi¹, Jan Borgomano², Jérôme Fortin², and Ian Jackson¹

¹Australian National University, Research School of Earth Sciences, Canberra, Australia (ian.jackson@anu.edu.au)

²Ecole Normale Supérieure/CNRS, UMR8538, PSL Research University, Paris, France, Laboratoire de Géologie

To test theoretical models of modulus dispersion and dissipation in fluid-saturated rocks, we have investigated the broadband mechanical properties of four thermally cracked glass specimens of simple microstructure with complementary forced-oscillation (0.004 -100 Hz) and ultrasonic techniques (~1MHz). Strong pressure dependence of moduli (bulk, Young's, and shear), axial strain, and ultrasonic wave speeds for dry conditions, attests to essentially complete crack closure at a confining pressure of 15 MPa – indicative of ambient-pressure crack aspect ratios mainly $< 2 \times 10^{-4}$. Oscillation of the confining pressure reveals bulk modulus dispersion and a corresponding dissipation peak, near 2 mHz only at the lowest effective pressure (2.5 MPa) – attributed to the transition with increasing frequency from the drained to saturated-isobaric regime. The observations are consistent with Biot-Gassmann theory, with dispersion and dissipation adequately represented by a Zener model. Above the draining frequency, axial forced-oscillation tests show dispersion of Young's modulus and Poisson's ratio, and an associated broad dissipation peak centred near 0.3 Hz, thought to reflect local 's squirt' flow and adequately modelled with a continuous distribution of relaxation times over two decades. Observations of Young's and shear modulus dispersion and dissipation from complementary flexural and torsional oscillation measurements for differential pressure ≤ 10 MPa provide supporting evidence of the transition with increasing frequency from the saturated-isobaric to the saturated-isolated regime – also probed by the ultrasonic technique. These findings validate predictions from theoretical models of dispersion in cracked media and emphasize need for caution in the seismological application of laboratory ultrasonic data for cracked media.