Geophysical Research Abstracts
Vol. 21, EGU2019-6335, 2019
EGU General Assembly 2019

Broadband mechanical properties and fluid flow regimes in cracked and fluid-saturated glass

Abdulwaheed Ògúnsàmì (1), Jan V.M. Borgomano (2), Jérôme Fortin (2), and Ian Jackson (1)

(1) Research School of Earth Sciences, Australian National University, ACT, Australia (ian.jackson@anu.edu.au), (2) Laboratoire de Géologie, Ecole Normale Supérieure/CNRS, UMR8538, PSL Research University, Paris, France

The frequency dependence of seismic properties of fluid-saturated crustal rocks makes it difficult to reconcile laboratory ultrasonic measurements of effective moduli (∼MHz range) with lower frequency field data from the borehole (∼tens of kHz) and exploration (∼10–100 Hz) geophysics. While carefully-executed laboratory broadband measurements appear promising for such reconciliation, the complex nature of rock microstructures constitutes a significant difficulty in the interpretation of such measurements – posing a limit to rigorous and conclusive testing of the theories relating the frequency dependent seismic properties of fluid-saturated media to microstructures and fluid flow regimes. In addressing this problem, we have tested the broadband mechanical behaviour of fluid-saturated specimens of cracked soda-lime-silica glass with simpler microstructures. A population of uniformly low aspect ratio cracks was introduced with heat treatment, yielding crack porosities consistently <1%, calculated from the difference in dimensions of each specimen, before and after thermal cracking. Permeability measurements with argon, pentane and water successively as pore fluids using either steady or transient flow methods were conducted to assess the fluid-flow properties of the specimens. To understand their mechanical behaviour across a wide range of frequencies, a combination of techniques was used to measure the mechanical properties of the dry and fluid-saturated conditions: oscillation of axial stress for Young's modulus and Poisson's ratio, oscillation of confining-pressure for bulk modulus, and torsional and flexural oscillation for shear and Young's moduli. The measurements were made at differential pressures (P_d = P_c - P_f) as low as 2.5 MPa to best observe the behaviour of the low-aspect-ratio cracks. The specimens exhibit pressure and frequency-dependent variations of both modulus and dissipation. The measurements at low frequency on these specimens of low crack porosity successfully sample various fluid-flow regimes. A shear modulus increase with increasing frequency in water-saturated conditions, consistent with saturated-isolated conditions, is found in the torsional oscillation tests and in the axial oscillation measurements with P_d > 2.5 MPa. The axial oscillation tests at P_d > 2.5 MPa reveal the transition with decreasing frequency below 0.6 Hz, between saturated-isolated and saturated-isobaric regimes, whereas the draining transition is observed at frequencies < 0.04 Hz in the confining-pressure oscillation tests.