Frequency effects on elastic properties of saturated porous rocks: Experimental investigations

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Comparing ultrasonic measurements (1 MHz) in the laboratory and seismic (100 Hz) or logging (10 kHz) measurements at the field scale is not straightforward due to the dispersion of body-wave velocities. In rocks fully saturated by a Newtonian fluid, dispersion is related to fluid flow at different scales, separating three regimes: the drained, undrained, and unrelaxed regimes.

In this work, the elastic dispersion and attenuation of different sedimentary rocks have been measured over a large frequency range. To cover the frequency range, forced oscillations (0.004 to 100 Hz) and ultrasonic (1 MHz) measurement techniques were done in a triaxial cell, at various differential pressures, on samples saturated by fluids of very different viscosity. The forced oscillations include both hydrostatic and axial oscillations to deduce the bulk and Young moduli, respectively.

For all the samples, we observe the drained–undrained transition and its consequence on the attenuation and the elastic moduli dispersion. Biot-Gassmann’ s theory is found to be valid to explained the increased of the elastic moduli from the drained to the undrained regime. Some samples exhibit a second transition from the undrained to the unrelaxed regime, and is explained a squirt-flow mechanism. For this second transition, the rock microstructure, especially the crack density and the crack aspect ratio seems to be the major contributor of the magnitude of the dispersion and attenuation.

Keywords: porous rock, velocity dispersion, squirt-flow

