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Measurements of seismic wave attenuation for frequencies between 0.1 and 100 Hz in a Paterson Rig

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The study of wave attenuation in partially saturated porous rocks over a broad frequency range provides valuable information about reservoir fluid systems, which are inherently composed of multiple phase fluid.
Following an original idea initiated by Luigi, we designed and set up a specific instrument, the Seismic Wave Attenuation Module (SWAM), to experimentally measure the bulk attenuation on partially saturated rocks at frequencies between 0.01 and 100 Hz, using natural rock samples under in situ conditions. We present its bench-top calibration, a series of data collected from different kind of rocks at different confing pressure and the numerical simulations, supporting the obtained results.
We employ the sub-resonance test. Assuming that the rock behaves as a linear time invariant (LTI) system, the attenuation factor 1/Q (Q is the quality factor) is equal to the tangent of the phase shift between the stress and the strain signal.
The new attenuation measurement equipment is calibrated in a gas apparatus (Paterson rig) using aluminum as elastic standard and Plexiglas as a viscoelastic standard. Measurements were performed on 25.4 mm diameter, 60 mm long samples. Berea sandstone samples with 20% porosity, and $\sim$500 mD permeability have been measured at different saturation conditions. Attenuation measurements show dependence upon saturation.
Moreover, measurements on two well-characterized shale samples have been performed. The two shales have significantly different quality factors; which result to be dependent on both the saturation state of the samples and the propagation direction of the oscillatory signal with respect to the sedimentary bedding. The attenuation coefficient parallel to bedding is less than that vertical to bedding.

Thanks to Luigi's initiative and inspiration two generations of his Ph.D. students are now able to jointly present these new challenging experimental results.