FREQUENCY-DEPENDENT Q ESTIMATION METHOD BASED | ON LABORATORY EXPERIMENTS

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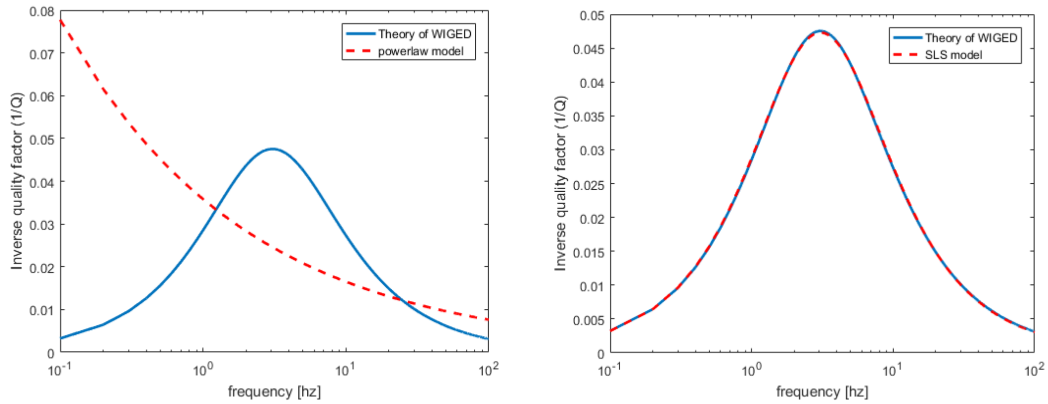
ABSTRACT

Attenuation, the inverse of the quality factor (Q), describes how seismic waves lose energy while propagating in a material. In many attenuation (1/Q) estimation schemes, we generally assume that Q is frequency independent or described by a power-law. However, such assumption used, for instance in the Log Spectral Ratio, introduces a systematic bias in the estimation of Q. Instead, the estimation of attenuation from field data should be considered as frequency-dependent. One approach to consider frequency-dependent Q is the knowledge of attenuation mechanisms for different saturation-lithology scenarios. Here, we estimate the frequency-dependent Q of a saturated rocks by means of laboratory experiments and the corresponding attenuation mechanism: the wave-induced gas exsolution dissolution (WIGED) mechanism. Machine calibration is implemented by comparing the results with the theory. Further, to estimate the impact of Q on real seismic data, we simulate field-scale seismic reflection surveys with a numerical solver: Sofi3D. In Sofi3D, the frequency-dependent attenuation behavior is approximated by the general standard linear solid (GSLS) model. Attenuation in the GSLS model is controlled by three parameters: relaxation time (τ), relaxation frequency (f_C), and the number of relaxation mechanism (L). We fit the GSLS model to the results from laboratory measurements in a least-squares sense. Then, we implement the model in the numerical simulation. Modified Log Spectral Ratio method is applied on synthetic reflection to estimate τ value. For certain saturation-lithology scenario, the shape of Q curve, which is controlled by L and f_C, is assumed not changed. Thus Frequency-dependent Q is finally calculated using τ, L and f_C. We show that Q, approximated from the synthetic reflection events, could not be explained with a constant or a power law Q model. Further work will be focused on performing experiments on attenuation measurements on fluids with bubbles and saturated rocks, and estimate frequency-dependent Q by designing a modified Log Spectral Ratio method for τ value estimation. This frequency-dependent Q estimation theory will then be applied on other attenuation mechanisms (wave-induced fluid flow, WIFF) in fluid saturated rocks.



Left: Comparison of frequency-dependent Q from theory of WIGED with power-law model. The Q of WIGED cannot be described by with power-law model. Right: Comparison of frequency-dependent Q from theory of WIGED with GSLS model. For two relaxation mechanisms, the optimistic corresponding τ value and relaxation times are obtained by minimizing the objective function. The Q of WIGED can be well described by GSLS model.