



Determining P- and S-wave velocities and Q-values from single ultrasound transmission measurements performed on cylindrical rock samples: it's possible, when...

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Determining elastic wave velocities and intrinsic attenuation of cylindrical rock samples by transmission of ultrasound signals appears to be a simple experimental task, which is performed routinely in a range of geoscientific and engineering applications requiring characterization of rocks in field and laboratory. P- and S-wave velocities are generally determined from first arrivals of signals excited by specifically designed transducers. A couple of methods exist for determining the intrinsic attenuation, most of them relying either on a comparison between the sample under investigation and a standard material or on investigating the same material for various geometries.

Of the three properties of interest, P-wave velocity is certainly the least challenging one to determine, but dispersion phenomena lead to complications with the consistent identification of frequency-dependent first breaks. The determination of S-wave velocities is even more hampered by converted waves interfering with the S-wave arrival. Attenuation estimates are generally subject to higher uncertainties than velocity measurements due to the high sensitivity of amplitudes to experimental procedures. The achievable accuracy of determining S-wave velocity and intrinsic attenuation using standard procedures thus appears to be limited.

We pursue the determination of velocity and attenuation of rock samples based on full waveform modeling and inversion. Assuming the rock sample to be homogeneous - an assumption also underlying standard analyses - we quantify P-wave velocity, S-wave velocity and intrinsic P- and S-wave attenuation from matching a single ultrasound trace with a synthetic one numerically modelled using the spectral finite-element software packages SPEC-FEM2D and SPEC-FEM3D. We find that enough information on both velocities is contained in the recognizable reflected and converted phases even when nominal P-wave sensors are used. Attenuation characteristics are also inherently contained in the relative amplitudes of these phases due to their different travel paths. We present recommendations for and results from laboratory measurements on cylindrical samples of aluminum and rocks with different geometries that we also compare with various standard analysis methods. The effort put into processing for our approach is particularly justified

when accurate values and/or small variations, for example in response to changing P-T-conditions, are of interest or when the amount of sample material is limited.