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Geometric Limitations of Ultrasonic Measurements: The Effect of Sample Surface Geometry on Sidewall Reflections

C. von Nicolai (1,2), J. Kummerow (1), F. Schilling (1,2), S. Jahn (1)

(1) GeoForschungsZentrum Potsdam, Germany, (2) Freie Universität Berlin, Germany

(bambi@gfz-potsdam.de)

The determination of elastic properties of rocks and minerals by ultrasonic measurements is a widely used tool in Geosciences. This is due to their high capability in many experimental set ups even at extreme conditions. The usability of ultrasonic data, however, strongly depends on their quality which is controlled by the sample geometry and the wavelength of the sound wave.

The most essential parameter restricting ultrasonic measurements dimensionally is the sample diameter-to-wavelength ratio d/λ. For cylindrical geometries the d/λ-ratio can be described very accurately by a quadratic equation $d^2/\lambda \approx 63$ for many materials. At smaller d^2/λ-ratios weakening of the direct wave signal due to interferences with sidewall reflections is too strong to allow interpretation and thus usage of ultrasonic data. In this study, we tested several different sample surface shapes in order to find a possibility to eliminate sidewall reflection effects.

Under well-defined conditions a series of experiments was run on Aluminium rods of constant length and variable diameter but different surface geometry. The experimental results show that there are some surface shapes at which only few, weak sidewall echoes are excited. Others, in contrast, have no significant effect on the generation of disturbing sidewall reflections. This indicates that the appearance of sidewall reflected waves may be depleted by a variation in sample surface shape, which, in turn, may allow the application of diameter-to-wavelength ratios smaller than $d^2/\lambda \approx 63$.