Seismic Velocities of Rocks: Numerical Comparison of Calculated Data with Experiment

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Seismic properties of rocks are mainly a function of their mineral composition, crystallographic orientation of main rock-forming minerals, number and orientation of micropores and type of pore fluids. Two basic laboratory methods can be used for finding seismic properties of rock: experimental measurement on rock samples or computation based on single-crystal elastic constants. The advantage of the experimental method is that it is applicable to rocks with complex structure and composition and it directly shows the effects of pores under various confining pressures. However, as the direct experimental method can not be used for rocks whose primary composition has changed during their uplift and exhumation, it is convenient to substitute the experiment with the numerical method.

Here we present our methodical approach to comparative analysis of experimentally measured and calculated velocities of longitudinal elastic waves (P-waves) in rock samples. For experiment, an ultrasonic pulse-transmission method of Pros (1998) was used. The experimental apparatus is designed for spherical rock sample, which is placed in high-pressure vessel and rotated along two perpendicular axes. The measurements are carried out under confining pressure of 400 MPa to suppress the influence of micropores, and repeated in 132 directions to get the 3-D dataset.

For the calculation of P-wave velocities and numerical comparison with experimental results special computer program has been developed (written by R. Melichar). The calculation is based on finding the elastic stiffness tensor for an aggregate of all constituent mineral phases. For each mineral phase the crystallographic orientation distribution is measured using EBSD method. Then the elastic stiffness tensors of all phases is computed with use of single crystal elastic constants. Based on stiffness tensors, volume fractions and densities of mineral phases, the aggregate stiffness tensor can be calculated using selected elastic mixture rule.

As the experimental velocities are measured at 400 MPa of confining pressure, the calculated stiffness tensors of constituent mineral phases have to be pressure-corrected prior to further processing. After the unification of coordinate systems of the two datasets to be compared, discrete experimental data are interpolated and numerically compared with the calculated data in a dense grid. The spatial distribution of the deviations is visualised in stereodiagrams.

Basing on the results the suitability of the two methods and the applicability of various combinations of Voigt and Reuss elastic mixture rules can be discussed. These comparative analyses could also reveal the residual influence of microstructure or micropores s.l. on seismic properties, if it exists. Examples are given in the contribution.

References

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Can Ternary Feldspars be Used to Constrain the Metamorphic Conditions of High-Grade Meta-Igneous Rocks? Evidence from Orthopyroxene Gneisses, Bohemian Massif

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The presence of ternary feldspars in high-grade meta-igneous rocks, and the recognition of the thermometric significance of these feldspars, has led recent workers to postulate peak-metamorphic temperatures in excess of 1000 °C. However it needs to be established that such ternary feldspars are not in fact survivors from the original high-temperature crystallisation of the