

Abstract

The presented work evaluates the significance of measuring acoustic S-wave velocities for determination of elastic anisotropy of rocks. The S waves are more sensitive to anisotropic properties of a medium than the P waves. Analyzing the S-wave splitting, it is possible to determine strength of anisotropy as well as the orientation of structures responsible for the anisotropic behavior of the medium. The S waves are necessary for determining the complete tensor of elastic parameters. In order to record the S waves, the measuring head of the present apparatus has been significantly adapted. Implemented innovations provided measurements of the P waves together with two orthogonally polarized S waves. The calibration performed on homogeneous isotropic materials proved that the recorded data are accurate and of high quality. The ultrasonic measurements on spherical samples under confining pressure and recording of the S waveforms significantly improved the accuracy of the retrieved elastic parameters compared to the measurements in standard use. The analysis of the S-wave records also required modifications of the processing software and a development of new algorithms. The proposed methods were tested on synthetic data. The tests evaluated the robustness of the inversion for anisotropy as a function of the number of measurements, their accuracy and type of waves recorded. The tests revealed that measuring the P-wave velocities is not sufficient for calculating the complete tensor of elastic parameters. When using measurements of the P- and S1-wave velocities, the accuracy is usually improved. However, the best accuracy is achieved if measurements of the P-, S1- and S2-wave velocities are inverted. The results of the synthetic tests were confirmed by the application of the proposed inversion methods to real data. This application documented the necessity for knowledge of the S1- and S2-wave velocities measured in a sufficient number of independent directions in order to determine anisotropy reliably.