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Inversion of P-wave traveltimes from a VSP experiment in moderately anisotropic media

Bohuslav Ruzek and Ivan Psencik
Czech Republic (b.ruzek@ig.cas.cz)

Determination of seismic anisotropy plays an important role, both in structural and exploration seismology. Knowledge of the orientation and strength of anisotropy has important geological implications as, e.g., estimation of the orientation of structural elements (layering, dikes, fissures) or of the orientation of the tectonic stresses. In this contribution, we present results of the inversion of synthetic P-wave traveltimes based on weak-anisotropy (WA) approximation. In this approximation, traveltimes depend on 15 P-wave WA parameters representing an alternative to commonly used parameters in the Voigt notation. A vertical seismic profiling (VSP) configuration was considered, because it guarantees a good angular illumination of the medium necessary for recovery of anisotropy. As observed data, synthetic P-wave traveltimes generated by program package ANRAY in orthorhombic media of arbitrary orientation, with added Gaussian noise were used. Different inversion methods were applied (both linear and non-linear ones). Results of the inversion are estimates of WA parameters, their resolution and accuracy. Resolution depends strongly on the measurement configuration and can be used for selecting the optimum measurement setup. WA parameters' accuracy depends both on measurement geometry and noise level in traveltime data. A number of synthetic tests for varying source-receiver configurations, varying noise types/levels, etc. were performed. In order to get complete and reliable information about the anisotropy, top-quality traveltime data are necessary. Tested inversion approaches can be directly used to estimate anisotropy of rock samples in laboratory ultrasonic sounding. They also represent an important basis for the traveltime inversion in more realistic structures. Such procedures may found applications in, for example, oil industry.