The Determination of Anisotropic Parameters from Wide-Angle Seismic Reflection Polarizations: A Model Study

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Abstract
As a main anisotropic parameter, generally, S-wave velocity is obtained by S-wave data or the empirical ratio from the P-wave to S-wave velocity (e.g., 1.75). Here, we present a simple inversion method which use seismic P-wave polarizations data to determine vertical SV-wave velocity v_{so} as well as another three anisotropic parameters (vertical P-wave velocity v_{po} and Thomsen's parameters ε and δ) (Thomsen, 1986) in 2D layered transversely isotropic media with a vertical symmetry axis (VTI) (Tsvankin, 1996). The vertical P-wave velocity and Thomsen's parameters are first obtained from the inversion of seismic P-wave reflection traveltimes, and then they are imputed as the corresponding initial parameters for the inversion of seismic P-wave polarizations. A nonlinear global optimization technique named Simulated Annealing (SA) (Rothman, 1985) is applied to both inversions (traveltimes and polarizations). The test results indicate that our inversion strategy is successful in providing favourable constrains to the SV-wave velocity and other anisotropic parameters.

Forward Computation
The shooting two-point ray tracing method is used in our forward computation of seismic P-wave reflection traveltimes and polarizations. Unlike the early paper by Chen and others (2009), we develop a more complex formulation for 2D VTI media and with undulating interfaces. Each layer boundary is specified by an arbitrary number of nodes connected by polynomial linkage and unevenly spaced along the boundary. It is assumed that any layer discontinuity cross the model from left to right without crossing points between boundaries. For some special cases in which the seismic rays can't reach the receivers due to the limitation of shooting two-point ray tracing, we implement cubic spline interpolation to obtain reflection traveltimes and polarization data at stations.

Inversion
For the performance of inversion, the reflection traveltimes and polarizations data (obtained from forward computation) are first reconstructed by adding Gaussian noise with the standard deviation of ±0.1 s and ±0.1°, respectively. The starting model is selected as isotropy model. During SA procedure, the initial temperature is 15^0. The vertical P-wave velocities and Thomsen parameters are obtained from the inversion of P-wave reflection traveltimes, and then are imputed as starting model into the inversion of P-wave reflection polarizations. The initial model, real model, inversion results from traveltimes data and final inversion results from polarizations data are shown in Figure 1. Figure 1a, 1b, 1c and 1d represent curves of vertical P-wave velocity, SV-wave velocity and Thomsen's parameters, respectively. Not only can we obtain SV-wave velocity from polarization inversion, but also we get P-wave velocity and Thomsen's parameters which are much closer to the real model than those from traveltimes inversion.

Conclusions
A simple inversion procedure of seismic P-wave polarizations for determining anisotropic parameters is presented here. Based on the success of the model test, application to real seismic data will be found in the future study.

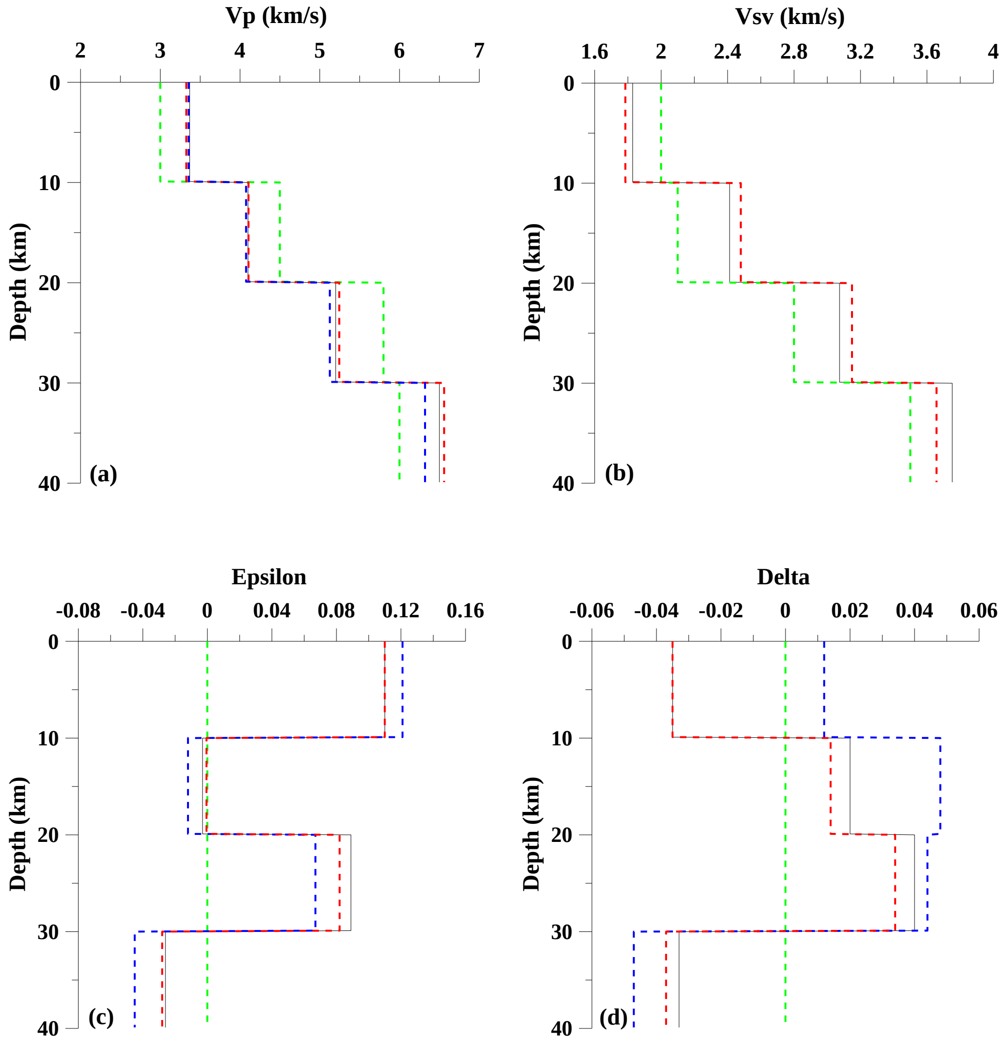

Figure 1. The vertical P-wave velocity (a), vertical SV-wave velocity (b) and Thomsen parameters (c) and (d) as derived by our inversion strategy. The light solid black lines, the solid green lines, the solid dashed blue lines and the solid dashed red lines indicate true model, starting model, inversion results from travel- times and final inversion results from polarizations, respectively.

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