Kirchhoff prestack depth scalar migration of complete wave fields in simple inhomogeneous weakly anisotropic velocity models: PP, PS1 and PS2 waves

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Summary
We use the 3-D ray-based Kirchhoff prestack depth scalar migration to calculate migrated sections in two simple inhomogeneous weakly anisotropic velocity models. Each velocity model is composed of two layers separated by a curved interface. The upper layer is inhomogeneous weakly anisotropic and the bottom layer is isotropic. The “recorded” complete seismic wave fields are calculated using the Fourier pseudospectral method. We apply the 3-D Kirchhoff prestack depth scalar migration to a single-layer velocity model with the same anisotropy as in the upper layer of the velocity model used to calculate the recorded wave field. We migrate the recorded wave field using three different ray-theory approximations of S waves: (a) common S-wave approximation of both S waves, (b) anisotropic-ray-theory approximation of S waves, (c) prevailing-frequency approximation of the coupling ray theory for S waves. We show and discuss the results of the migration of the complete wave field.

Keywords
Fourier pseudospectral method, 3-D Kirchhoff prestack depth scalar migration, anisotropic velocity model, weak anisotropy, complete wave field, coupling ray theory

1. Introduction
Bucha (2018) migrated a complete wave field calculated by the Fourier pseudospectral method (Tessmer, 1995), while in the preceding studies he migrated separate ray-theory elementary waves. This paper extends the paper by Bucha (2018) in which he used common S-wave approximation to migrate the S-wave part of the converted PS wave. In this paper, we supplement the results of migration using the anisotropic-ray-theory approximation of S waves, and the prevailing-frequency approximation of the coupling ray theory for S waves (Klimeš & Bulant, 2016). The calculations are performed in the inhomogeneous weakly anisotropic velocity models QI, which was used by Bucha (2018), and newly also in the velocity model QI4 with stronger anisotropy.

The dimensions of the velocity model and the shot-receiver configuration are the same as in the previous papers by Bucha (e.g., 2012, 2013, 2017), where he studied the sensitivity of the migrated images to incorrect anisotropy, to incorrect gradients of elastic moduli or to incorrect rotation of the tensor of elastic moduli (stiffness tensor).

To compute the synthetic recorded wave field, we use simple anisotropic velocity models composed of two layers separated by one curved interface that is non-inclined in
the direction perpendicular to the source-receiver profiles. The inhomogeneous upper layer is weakly anisotropic and the bottom layer is isotropic. The velocity models for the Fourier pseudospectral method are extended by absorption stripes at the sides.

We then migrate complete wave field using 3-D ray-based Kirchhoff prestack depth scalar migration in the single-layer inhomogeneous weakly anisotropic velocity models. Under the “scalar” migration, we understand here the migration of just a single component of the recorded elastic wave field. The elastic moduli in the velocity model used for migration correspond to the upper layer of the velocity model in which the synthetic recorded seismograms have been calculated. For migration we utilize the MODEL, CRT, FORMS and DATA software packages (Červený, Klimeš & Pšenčík, 1988; Bulant, 1996; Bucha & Bulant, 2018).

2. Anisotropic velocity models

The dimensions of the velocity models and the measurement configuration are derived from the 2-D Marmousi model and dataset (Versteeg & Grau, 1991). The horizontal dimensions of the velocity models are $0 \text{ km} \leq x_1 \leq 9.2 \text{ km}$, $0 \text{ km} \leq x_2 \leq 10 \text{ km}$ and the depth is $0 \text{ km} \leq x_3 \leq 3 \text{ km}$. The velocity models are composed of two layers separated by one curved interface (see Figure 1). The curved interface is non-inclined in the direction of the $x_2$ axis which is perpendicular to the source-receiver profiles.

![Figure 1. Velocity model with a curved interface and with inhomogeneous weakly anisotropic upper layer. The horizontal dimensions of the velocity model are $0 \text{ km} \leq x_1 \leq 9.2 \text{ km}$, $0 \text{ km} \leq x_2 \leq 10 \text{ km}$ and the depth is $0 \text{ km} \leq x_3 \leq 3 \text{ km}$. The velocity model contains one curved interface which is non-inclined in the direction perpendicular to the source-receiver profiles.](image)

The recorded wave field is computed in the velocity models composed of two layers. The medium in the upper layer of the velocity models is inhomogeneous, weakly anisotropic. We use anisotropy proposed by Bulant and Klimeš (2008) in the models QI and QI4 for the illustration of coupling effects. The model QI coincides with the WA model of Pšenčík and Dellinger (2001). The model QI was also used by Farra and Pšenčík (2010) for a comparison of the coupling ray theory based on FORT with the standard ray theory results. The QI model is vertically inhomogeneous, transversely isotropic with a horizontal axis of symmetry (HTI). The axis of symmetry is rotated counterclockwise everywhere in the plane $(x_1, x_2)$ by $45^\circ$ from the $x_1$ axis. The QI4 model is derived from the QI model and has stronger anisotropy.
The matrix of density-reduced elastic moduli of model QI in km²/s² reads
at z = 0 km:
\[
\begin{pmatrix}
14.48500 & 4.52500 & 4.75000 & 0.00000 & 0.00000 & -0.58000 \\
14.48500 & 4.75000 & 0.00000 & 0.00000 & -0.58000 \\
15.71000 & 0.00000 & 0.00000 & -0.29000 \\
5.15500 & -0.17500 & 0.00000 \\
5.15500 & 0.00000 \\
0.00000 & 0.00000 & -0.58000
\end{pmatrix}
\]
and at z = 2.9 km:
\[
\begin{pmatrix}
22.08963 & 6.90063 & 7.24375 & 0.00000 & 0.00000 & -0.88450 \\
22.08963 & 7.24375 & 0.00000 & 0.00000 & -0.88450 \\
23.95775 & 0.00000 & 0.00000 & -0.44225 \\
7.86138 & -0.26688 & 0.00000 \\
7.86138 & 0.00000 \\
7.69363
\end{pmatrix}
\]
(1)
The values of anisotropy strength defined as \(2(P_{\text{max}} - P_{\text{min}})/(P_{\text{max}} + P_{\text{min}}) \times 100\%\), where \(P_{\text{min}}\) and \(P_{\text{max}}\) are minimum and maximum absolute norms of the slowness vector, for model QI are: 8.0 % for P wave, 3.4 % for S1 wave and 0.3 % for S2 wave.

The values of anisotropy strength for model QI4 are: 36.7 % for P wave, 13.4 % for S1 wave and 4.5 % for S2 wave.

The matrix of density-reduced elastic moduli of model QI4 in km²/s² reads
at z = 0 km:
\[
\begin{pmatrix}
12.94000 & 3.70000 & 4.60000 & 0.00000 & 0.00000 & -2.32000 \\
12.94000 & 4.60000 & 0.00000 & 0.00000 & -2.32000 \\
17.84000 & 0.00000 & 0.00000 & -1.16000 \\
5.32000 & -0.70000 & 0.00000 \\
5.32000 & 0.00000 \\
4.88000
\end{pmatrix}
\]
and at z = 2.9 km:
\[
\begin{pmatrix}
19.35852 & 5.34252 & 6.71500 & 0.00000 & 0.00000 & -3.53800 \\
19.35852 & 6.71500 & 0.00000 & 0.00000 & -3.53800 \\
26.83100 & 0.00000 & 0.00000 & -1.76900 \\
8.07552 & -1.06752 & 0.00000 \\
8.07552 & 0.00000 \\
7.40452
\end{pmatrix}
\]
(2)
The values of anisotropy strength for model QI4 are: 36.7 % for P wave, 13.4 % for S1 wave and 4.5 % for S2 wave.

The P-wave velocity in the isotropic bottom layer is \(V_p = 3.6\) km/s and the S-wave velocity is \(V_s = V_p/\sqrt{3}\). We migrate in the single-layer velocity models (without the curved interface) with the same inhomogeneous anisotropies given by matrices (1) and (2). The elastic moduli in the velocity model for migration correspond to the upper layer of the velocity model in which the synthetic recorded data have been calculated.
3. Shots and receivers

The measurement configuration is derived from the Marmousi model and dataset (Versteeg & Grau, 1991). The profile lines are parallel with the $x_1$ coordinate axis. Each profile line has the following configuration: The first shot is 3 km from the left-hand side of the velocity model, the last shot is 8.975 km from the left-hand side of the velocity model, the distance between the shots is 0.025 km, and the depth of the shots is 0.025 km. The total number of shots along one profile line is 240. The number of receivers per shot is 96, the first receiver is located 2.575 km left of the shot location, the last receiver is 0.2 km left of the shot location, the distance between the receivers is 0.025 km, and the depth of the receivers is 0 km. This configuration simulates a simplified towed streamed acquisition geometry.

The 3-D measurement configuration consists of 81 parallel profile lines, see Figure 2. The interval between the parallel profile lines is 0.025 km.

4. Recorded wave field

To calculate the recorded wave field for 240 shots, we apply code FT43DANX by E. Tessmer (Tessmer, 1995). The code is based on the Fourier method (FM), a kind of pseudospectral method (e.g., Kosloff & Baysal, 1982). The code FT43DANX was previously used to test the accuracy of coupling ray theory and standard ray theory results in 3-D inhomogeneous, weakly anisotropic media without interfaces (Pšenčík, Farra & Tessmer, 2011; Bulant et al., 2011). This implementation of the FM is applicable to any type and strength of anisotropy. It works equally well in regular as well as in singular regions of the ray method.

The algorithm is based on a regular numerical grid. For simple structures with horizontal layering, the input parameters for velocity model are located in the main ASCII input file. The velocity model for our tests contains a curved interface. In such a case, the input structure for code FT43DANX needs to be gridded and saved in a separate binary file. We performed gridding of the velocity model using the MODEL and FORMS packages (Červený, Klimeš & Pšenčík, 1988; Bucha & Bulant, 2018). There are two limitations for setting grid sizes. The first is that the grid size numbers must be factorizable into the factors up to 23, and the FFT algorithm is the more efficient the smaller factors are. The second limitation is connected with the first one, the grid sizes must be odd numbers.

To avoid wrap-around or boundary reflections, the model is surrounded by sponge-like absorbing regions (Cerjan et al., 1985). This requires the numerical grid to be extended at its sides. We present calculation with 20 absorption grid points at the sides of the model. The enlarged model has numerical grid $405 \times 165 \times 189$ grid nodes in the $x_1$, $x_2$ and $x_3$ directions, respectively. The grid steps are 0.025 km. The horizontal dimensions of the velocity model are $0 \text{ km} \leq x_1 \leq 10.1 \text{ km}$, $0 \text{ km} \leq x_2 \leq 4.1 \text{ km}$, and the depth is $0 \text{ km} \leq x_3 \leq 4.7 \text{ km}$. The shot is situated 3.45 km from the left-hand side of the enlarged velocity model and the depth of the shot is 1.225 km. The number of receivers per shot is 96. The first receiver is 0.875 km from the left-hand side of the velocity model, the distance between the receivers is 0.025 km, and the depth of the receivers is 1.2 km (see Figure 3).

We use an explosive source for calculating the synthetic seismograms. The source-time function is a Gabor wavelet, $\exp[-(2\pi f/\gamma)^2 t^2] \cos(2\pi f t)$, with the dominant fre-
Figure 2. Part of the velocity model with 81 parallel profile lines, the curved interface (yellow) and the bottom velocity model plane (green). The horizontal dimensions of the depicted part of the velocity model are $0 \text{ km} \leq x_1 \leq 9.2 \text{ km}$, $3.5 \text{ km} \leq x_2 \leq 6.5 \text{ km}$, the depth is $0 \text{ km} \leq x_3 \leq 3 \text{ km}$. We compute and stack migrated sections in the 2-D plane (blue) located in the middle of the shot-receiver configuration, at horizontal coordinate $x_2 = 5 \text{ km}$.

quency $f = 25 \text{ Hz}$ and $\gamma = 4$. The time step for wave field calculation is $0.003 \text{ s}$ and the propagation time starts at $0 \text{ s}$ and ends at $2.5 \text{ s}$. The source must be away from the surface. Sources and receivers should be at least 5 grid points away from the absorbing boundaries. Source and receiver positions are specified by grid indices.

Due to the above mentioned limitations and requirements, it is not easy to find the suitable computational grid parameters. Moreover, numerical algorithms based on pseudospectral methods are computationally more expensive than finite-difference methods. We tested the Fourier method with various values of input parameters. The results in the paper correspond to our best selection up to date.

The recorded wave field is equal for all parallel profile lines, because the distribution of elastic moduli in the upper layer is vertically inhomogeneous, the bottom layer is homogeneous, and the non-inclined curved interface is independent of the coordinate $x_2$ perpendicular to the profile lines (2.5-D velocity model, see Figures 1 and 2).

The Fourier method calculates many waves in regions where the ray-theory method fails. For plotting Fourier method (FM) seismograms, we use the Seismic Unix plotting tools (Cohen & Stockwell, 2013). Seismograms are calculated and plotted up to the time of $2.5 \text{ s}$.

To see how complex the complete wave fields are, we display radial ($X_1$), transversal ($X_2$) and vertical ($X_3$) components for common-shot gather 1 calculated in the velocity models with the QI and QI4 anisotropies in the upper layer (see Figures 4 and 5). Figures 6 and 7 display radial ($X_1$), transversal ($X_2$) and vertical ($X_3$) snapshots of the wave field for common-shot gather 1.
Figure 3. Section of the enlarged velocity model with 20 absorption grid points for the FM calculation. The dimensions of the section are $0 \text{ km} \leq x_1 \leq 10.1 \text{ km}$ and $0 \text{ km} \leq x_3 \leq 4.7 \text{ km}$. The velocity model contains one curved interface which is non-inclined in the direction perpendicular to the source-receiver profiles. The depth of the shot is $1.225 \text{ km}$. The first receiver is $0.875 \text{ km}$ from the left-hand side of the velocity model, and the depth of the receivers is $1.2 \text{ km}$.

5. Kirchhoff prestack depth scalar migration

We use the MODEL, CRT, FORMS and DATA software packages for the ray-based 3-D Kirchhoff prestack depth scalar migration (Červený, Klímeš & Pšencík, 1988; Bulant, 1996; Bucha & Bulant, 2018). We migrate the complete wave field without decomposition.

The ray-based migration consists of two-parametric controlled initial-value ray tracing (Bulant, 1999) from the individual surface points, calculating the grid values of travel times and amplitudes by interpolation within ray cells (Bulant & Klímeš, 1999; Klímeš & Bulant, 2017), performing the common-shot Kirchhoff migration and stacking the migrated images. The shot-receiver configuration consists of 81 parallel profile lines at intervals of $0.025 \text{ km}$ (see Figure 2). The first profile line is situated at horizontal coordinate $x_2 = 4 \text{ km}$ and the last profile line is situated at horizontal coordinate $x_2 = 6 \text{ km}$. For migration we use the single-layer velocity models (without the curved interface) with the same inhomogeneous anisotropies as in the upper layers of the velocity models used to calculate the recorded wave field, given by matrices (1) and (2).

In our tests, we calculate only one vertical image section corresponding to the central profile line ($x_2 = 5 \text{ km}$, see Figure 2). Although it is only a 2-D profile line, such an image represents one vertical section of a full 3-D migrated volume. We form the image by computing and summing the corresponding contributions (images) from all 81 parallel source-receiver lines. While summing the contributions, the constructive interference focuses the migrated interface and the destructive interference reduces undesirable migration artefacts (non-specular reflections). We also use cosine taper to clear artefacts, but some of them remain.

In the ray-based 3-D Kirchhoff prestack depth scalar migration, we decompose both the incident wave field and the back-propagated recorded wave field into elementary waves $P$, $S_1$ and $S_2$. In this paper, we refer to the faster $S$ wave as the $S_1$ wave, and to the slower $S$ wave as the $S_2$ wave. If we migrate with the incident $P$ wave and the back-propagated $P$ wave, we speak about migrating the PP reflected wave, although we migrate the complete recorded wave field. Analogously, if we migrate with the incident $P$ wave and the back-propagated $S_2$ wave, we speak about migrating the PS2 converted
Figure 4. Radial (X1), transversal (X2) and vertical (X3) components of the complete wave field for common-shot gather 1. The complete seismic wave field is calculated using the Fourier pseudospectral method in the velocity model with the QI4 anisotropy in the upper layer.

Figure 5. Radial (X1), transversal (X2) and vertical (X3) components of the complete wave field for common-shot gather 1. The complete seismic wave field is calculated using the Fourier pseudospectral method in the velocity model with the QI4 anisotropy in the upper layer.

The migration is tested for the vertical (X3) component of the PP reflected wave, for the radial (X1) component and transversal (X2) component of PS1 and PS2 converted waves.

Bucha (2018) used the common S-wave approximation (CSA) of the S-wave part of the converted PS wave in his migration. In addition to that, we calculate the S-wave part of converted PS1 and PS2 waves by means of the anisotropic-ray-theory approximation (RTA) of S waves, and by means of the prevailing-frequency approximation (PFA) of the coupling ray theory for S waves (Klimeš & Bulant, 2016) in this paper.
Figure 6. Snapshots of the radial (X1), transversal (X2) and vertical (X3) components for common-shot gather 1, calculated in the velocity model with the QI anisotropy in the upper layer.
Figure 7. Snapshots of the radial (X1), transversal (X2) and vertical (X3) components for common-shot gather 1, calculated in the velocity model with the QI4 anisotropy in the upper layer.
The computations are performed in the inhomogeneous weakly anisotropic velocity model QI defined by matrix (1) and in the model QI4 with stronger anisotropy defined by matrix (2), respectively. All migrated sections displayed in this paper have stair-step interfaces caused by gridded velocity models. For detailed explanation of the stair-step problem, please refer to Bucha (2019).

Figures 8-12 display stacked sections migrated in the weakly anisotropic velocity model QI without interface. Figure 8 shows stacked migrated section calculated for the vertical (X3) component of the PP reflected wave. Figures 9-12 display stacked migrated sections for radial (X1) and transversal (X2) components of PS1 and PS2 converted waves. In Figures 9-12, three migrated sections corresponding to different approximations of S waves are compared: (a) common S-wave approximation (CSA) of both S waves, (b) anisotropic-ray-theory approximation (RTA) of S waves, (c) prevailing-frequency approximation (PFA) of the coupling ray theory for S waves.

The common S-wave approximation (CSA) calculates average travel times of S1 and S2 waves. In velocity model QI, with inhomogeneous weak anisotropy, the splitting of PS1 and PS2 waves is very small. In this case, the position of the migrated interface coincides with the original interface nearly perfectly. Please, compare with Figures 14-17 showing analogous migrated sections for model QI4 with stronger anisotropy and with greater splitting of PS1 and PS2 waves, where the common S-wave approximation (CSA) yields the migrated interface doubled around the original interface.

Stacked migrated sections are nearly equal for other two methods of calculating the S-wave part of converted PS1 and PS2 waves, the anisotropic-ray-theory approximation (RTA) and the prevailing-frequency approximation (PFA). In comparison with the common S-wave approximation (CSA) and the original interface, the resulting migration interfaces for RTA and PFA are slightly shifted downwards (for PS1) or upwards (for PS2). The shift corresponds to the different velocities of PS1 and PS2 waves. In model QI, the velocity differences and the splitting of S1 and S2 waves are very small in comparison with model QI4.

![Figure 8](image.png)

**Figure 8.** Stacked section migrated in the weakly anisotropic velocity model QI without interface. The vertical (X3) component of the PP reflected wave is considered. The elastic moduli in the single-layer velocity model for migration are the same as in the upper layer of the velocity model used to calculate the recorded wave field. 81 × 240 common-shot prestack depth migrated sections, corresponding to 81 profile lines and 240 sources along each profile line, have been stacked. The crosses denote the interface in the velocity model used to compute the recorded wave field.
Figure 9. Stacked sections migrated in the weakly anisotropic velocity model QI without interface. The radial (X1) component of the PS1 converted wave is considered. We compare three approaches for calculation of the S-wave part of the converted PS1 wave: common S-wave approximation (CSA), anisotropic-ray-theory approximation (RTA) and prevailing-frequency approximation (PFA). The elastic moduli in the single-layer velocity model for migration are the same as in the upper layer of the velocity model used to calculate the recorded wave field. 81 × 240 common-shot prestack depth migrated sections, corresponding to 81 profile lines and 240 sources along each profile line, have been stacked. The crosses denote the interface in the velocity model used to compute the recorded wave field. The top images of the interface in the two bottom figures (RTA, PFA) are correct, the false images are slightly shifted downwards.

In applying the anisotropic-ray-theory approximation (RTA) to velocity model QI, we encounter problems with anomalous amplitudes of the Green function for PS1 and PS2 waves. These anomalies yield additional migration artefacts (noise). We solved the problem by limiting the maximum value of the Green function. We do not observe the same problem for velocity model QI4 with stronger anisotropy.
Figure 10. Stacked sections migrated in the weakly anisotropic velocity model QI without interface. The transversal (X2) component of the PS1 converted wave is considered. We compare three approaches for calculation of the S-wave part of the converted PS1 wave: common S-wave approximation (CSA), anisotropic-ray-theory approximation (RTA) and prevailing-frequency approximation (PFA). The elastic moduli in the single-layer velocity model for migration are the same as in the upper layer of the velocity model used to calculate the recorded wave field. 81 × 240 common-shot prestack depth migrated sections, corresponding to 81 profile lines and 240 sources along each profile line, have been stacked. The crosses denote the interface in the velocity model used to compute the recorded wave field. The top images of the interface in the two bottom figures (RTA, PFA) are correct, the false images are slightly shifted downwards.

Figures 13-17 display stacked sections migrated in the anisotropic velocity model QI4 without interface for PP, PS1 and PS2 waves. The figures are analogous to Figures 8-12. For velocity model QI4, the splitting of PS1 and PS2 waves is considerable. The common S-wave approximation (CSA) yields the migrated interface doubled around the original interface.
Figure 11. Stacked sections migrated in the weakly anisotropic velocity model QI without interface. The radial (X1) component of the PS2 converted wave is considered. We compare three approaches for calculation of the S-wave part of the converted PS2 wave: common S-wave approximation (CSA), anisotropic-ray-theory approximation (RTA) and prevailing-frequency approximation (PFA). The elastic moduli in the single-layer velocity model for migration are the same as in the upper layer of the velocity model used to calculate the recorded wave field. $81 \times 240$ common-shot prestack depth migrated sections, corresponding to 81 profile lines and 240 sources along each profile line, have been stacked. The crosses denote the interface in the velocity model used to compute the recorded wave field. The bottom images of the interface in the two bottom figures (RTA, PFA) are correct, the false images are slightly shifted upwards.

Stacked migrated sections are nearly equal for other two methods of calculating the S-wave part of converted PS1 and PS2 waves, the anisotropic-ray-theory approximation (RTA) and the prevailing-frequency approximation (PFA). In Figures 14-17, the more pronounced image of the interface corresponds to the converted wave under consideration. The other of the PS1 and PS2 waves generates the spurious image which is
Figure 12. Stacked sections migrated in the weakly anisotropic velocity model QI without interface. The transversal (X2) component of the PS2 converted wave is considered. We compare three approaches for calculation of the S-wave part of the converted PS2 wave: common S-wave approximation (CSA), anisotropic-ray-theory approximation (RTA) and prevailing-frequency approximation (PFA). The elastic moduli in the single-layer velocity model for migration are the same as in the upper layer of the velocity model used to calculate the recorded wave field. 81 × 240 common-shot prestack depth migrated sections, corresponding to 81 profile lines and 240 sources along each profile line, have been stacked. The crosses denote the interface in the velocity model used to compute the recorded wave field. The bottom images of the interface in the two bottom figures (RTA, PFA) are correct, the false images are slightly shifted upwards. Unfortunately well visible. The spurious migrated interfaces for RTA and PFA are shifted downwards for the PS1 wave and upwards for the PS2 wave. The shift corresponds to the different velocities of PS1 and PS2 waves.
Figure 13. Stacked section migrated in the anisotropic velocity model QI4 without interface. The vertical (X3) component of the PP reflected wave is considered. The elastic moduli in the single-layer velocity model for migration are the same as in the upper layer of the velocity model used to calculate the recorded wave field. 81 × 240 common-shot prestack depth migrated sections, corresponding to 81 profile lines and 240 sources along each profile line, have been stacked. The crosses denote the interface in the velocity model used to compute the recorded wave field.

6. Conclusions
We have presented results of the 3-D ray-based Kirchhoff prestack depth scalar migration of complete wave fields in simple inhomogeneous weakly anisotropic velocity model QI and velocity model QI4 with stronger anisotropy. We have migrated the vertical component of the PP reflected wave, radial and transversal components of PS1 and PS2 converted waves. For the S-wave part of converted PS1 and PS2 waves, we have used and compared the common S-wave approximation, the anisotropic-ray-theory approximation and the prevailing-frequency approximation of the coupling ray theory.

In spite of complex recorded wave fields, the migrated interfaces are in all stacked migrated sections relatively good. The destructive interference reduces and smudges undesirable migration artefacts with exception of spurious interface images close to the correct ones.

Acknowledgements
The author thanks Ekkehart Tessmer for providing the Fourier method code. The author also thanks Ivan Pšenčík and Luděk Klimeš for their help throughout the work on this paper.

The research has been supported by the Ministry of Education of the Czech Republic within Research Project CzechGeo/EPOS LM2015079, and by the members of the consortium “Seismic Waves in Complex 3-D Structures” (see “http://sw3d.cz”).

References
Figure 14. Stacked sections migrated in the anisotropic velocity model QI4 without interface. The radial (X1) component of the PS1 converted wave is considered. We compare three approaches for calculation of the S-wave part of the converted PS1 wave: common S-wave approximation (CSA), anisotropic-ray-theory approximation (RTA) and prevailing-frequency approximation (PFA). The elastic moduli in the single-layer velocity model for migration are the same as in the upper layer of the velocity model used to calculate the recorded wave field. 81×240 common-shot prestack depth migrated sections, corresponding to 81 profile lines and 240 sources along each profile line, have been stacked. The crosses denote the interface in the velocity model used to compute the recorded wave field. The top images of the interface in the two bottom figures (RTA, PFA) are correct, the false images are displaced downwards.
Figure 15. Stacked sections migrated in the anisotropic velocity model QI4 without interface. The transversal (X2) component of the PS1 converted wave is considered. We compare three approaches for calculation of the S-wave part of the converted PS1 wave: common S-wave approximation (CSA), anisotropic-ray-theory approximation (RTA) and prevailing-frequency approximation (PFA). The elastic moduli in the single-layer velocity model for migration are the same as in the upper layer of the velocity model used to calculate the recorded wave field. 81×240 common-shot prestack depth migrated sections, corresponding to 81 profile lines and 240 sources along each profile line, have been stacked. The crosses denote the interface in the velocity model used to compute the recorded wave field. The top images of the interface in the two bottom figures (RTA, PFA) are correct, the false images are displaced downwards.
Figure 16. Stacked sections migrated in the anisotropic velocity model QI4 without interface. The radial (X1) component of PS2 the converted wave is considered. We compare three approaches for calculation of the S-wave part of the converted PS2 wave: common S-wave approximation (CSA), anisotropic-ray-theory approximation (RTA) and prevailing-frequency approximation (PFA). The elastic moduli in the single-layer velocity model for migration are the same as in the upper layer of the velocity model used to compute the recorded wave field. 81 × 240 common-shot prestack depth migrated sections, corresponding to 81 profile lines and 240 sources along each profile line, have been stacked. The crosses denote the interface in the velocity model used to compute the recorded wave field. The bottom images of the interface in the two bottom figures (RTA, PFA) are correct, the false images are displaced upwards.
Figure 17. Stacked sections migrated in the anisotropic velocity model QI4 without interface. The transversal (X2) component of the PS2 converted wave is considered. We compare three approaches for calculation of the S-wave part of the converted PS2 wave: common S-wave approximation (CSA), anisotropic-ray-theory approximation (RTA) and prevailing-frequency approximation (PFA). The elastic moduli in the single-layer velocity model for migration are the same as in the upper layer of the velocity model used to calculate the recorded wave field. 81 × 240 common-shot prestack depth migrated sections, corresponding to 81 profile lines and 240 sources along each profile line, have been stacked. The crosses denote the interface in the velocity model used to compute the recorded wave field. The bottom images of the interface in the two bottom figures (RTA, PFA) are correct, the false images are displaced upwards.


