Alaska Megathrust 2: Imaging the megathrust zone and Yakutat/Pacific plate interface in the Alaska subduction zone.

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1. Introduction

Auxiliary material for this article contains the results from the sensitivity tests on different projection angles and background models. In this test, we project MOOS and BEAAR stations along a various range of projection angles to ensure that updip slab contortions do not bias the image. Finally, we include the captions for the Supplementary Figures.

2. Sensitivity to different projection angles and background models

Rondenay et al. [2010] previously explored the resolution of the migration image from the 2-D GRT method by using a range of projection angles and event sets based on the BEAAR dataset. They suggested a downdip azimuth of N150°E (N330°E)±10° produces the most focused signal from the low-velocity subducting crust and beneath central Alaska (horizontal location > 210 km on Figures 3 and 4). We also find that the same projection angle of (N330°E±10°) yields the most focused image of the overall structure along the continuous transect (A-A') beneath both MOOS and BEAAR stations (Supplementary Fig. S6), which is not surprising since the northern half of our data set is nearly identical to that of the earlier study, and dips are relatively low (<10°) in the southern half.

We also test a range of projection lines from a subset of MOOS stations (Supplementary Figs S7a and S8a), and find that the optimal projection azimuths are (1) N290°E±10° (B-B') for imaging the Pacific plate in the west of the array near Cook Inlet, and (2) N330°E±10° (A-A'') for imaging the thin low-velocity feature (thrust zone) atop the Yakutat terrane beneath southern Alaska. These variations reflect the 3D bending of the slab, but because dip is small beneath most of the Kenai, either dip gives good recovery of thrust zone structure. As the projection angle changes away from the optimal azimuth, migration artifacts such as "migration smiles" appear due to insufficient spatial sampling.

The same background model is used for both the migration and hypocenter relocation to minimize the source of bias when comparing the location of imaged structures and seismicity. For the profile A-A', we use (1) 1-D velocity model (Table 1) that was previously used in the migration using BEAAR dataset [Rondenay et al., 2008; 2010], and (2) 1-D velocity model (Table 2) that is consistent with the "Kenai" velocity model used in the relocation of local seismicity recorded from the MOOS array [Li et al., 2013]. For the short profiles B-B' and A-A'', we only use the Kenai model (Table 2). We find that the choice of background models only influences the depth of imaged structures (Supplementary Fig. S13). The BEAAR model (Table 1) resolves the depth and dip of a thick subducted crust to be fully consistent with previous RF analysis [Ferris et al., 2003; Rossi et al., 2006] and with the relocated seismicity beneath

BEAAR stations in central Alaska (Supplementary Fig. S12). The Kenai model (Table 2) best resolves the shallowly dipping low-velocity thrust zone (Supplementary Figs S7b and S8b; Figure 5).

Figure captions

Supp_Figure1.eps (Figure 1) Radial receiver functions (RFs) for station DEVL. a. RFs sorted according to the ray parameter indicated at the left of each RF trace. The predicted arrival times of the primary phase (Ps) and two multiples (PpPs and PsPs) from the top of the low-velocity thrust zone are marked by the solid and dashed lines. b. RFs after PpPs moveout correction. The arrival times of the PpPs phase is marked by the dashed line. We apply a factor 2.0 on the stacked waveforms (shown in blue) to boost amplitudes.

Supp_Figure2.eps (Figure 2) Teleseismic earthquake locations used in receiver function (RF) analysis. Total 66 earthquakes recorded from MOOS with the magnitude ranging between 6.0 and 7.3 are processed. Two dashed lines are a distance of 30 and 90 degrees away from the center of the array (shown as a dark gray square).

Supp_Figure3.ps (Figure 3) Images showing individual mode contributions across the profile B-B'. a-e. Contributions from each scattering modes for one forward (Ps) and four backscattered modes (PpPp, PpPs, PpSs|v, and PsSs|h). Red to blue color scale represents negative (slower) to positive (faster) P-wave and S-wave velocity perturbations relative to the 1-D background model (Table 2). f. Composite dVs/Vs image.

Supp_Figure4.ps (Figure 4) Images showing individual mode contributions across the profile A-A". a-e. Contributions from each scattering modes for one forward (Ps) and four backscattered modes (PpPp, PpPs, PpSs|v, and PsSs|h). Red to blue color scale represents negative (slower) to positive (faster) P-wave and S-wave velocity perturbations relative to the 1-D background model (Table 2). f. Composite dVs/Vs image.

Supp_Figure5.eps (Figure 5) Stacked RFs along the A-A'' using a subset of MOOS stations (Figure 4d, red squares including a black one) including station KASH which was not used in the migration.

Supp_Figure6.eps (Figure 6) a. Seven projection azimuths. Stations that are not included in the migration are shown as gray. b. Composite dVs/Vs images from different projection angles. The most focused and coherent seismic signals can be found in the image produced by the azimuth of N330E±10 degrees. Red to blue color scale represents negative (slower) to positive (faster) dVs/Vs relative to the 1-D background model (Table 1).

Supp_Figure7.eps (Figure 7) a. Eight projection azimuths. Stations that are not included in the migration are shown as gray. b. Composite dVs/Vs images from different projection angles. The most focused and coherent seismic signals can be found in the image produced by the azimuth of N330E±10 degrees. Red to blue color scale represents negative (slower) to positive (faster) dVs/Vs relative to the 1-D background model (Table 2).

Supp_Figure8.eps (Figure 8) a. Six projection azimuths. Stations that are not included in the migration are shown as gray. b. Composite dVs/Vs images from different projection angles. The most focused and coherent seismic signals can be found in the image produced by the azimuth of N290E±10 degrees. Red to blue color scale represents negative (slower) to positive (faster) dVs/Vs relative to the 1-D background model (Table 2).

Supp_Figure9.eps (Figure 9) Synthetic RFs and velocity models for station DEVL. a. Synthetic traces computed for the thickness, h = 1 – 6 km with the fixed P-to-S velocity ratio, *Vp*/*Vs*. b. Synthetics computed for *Vp*/*Vs* = 1.8 – 2.3 with the fixed h.

Supp_Figure10.eps (Figure 10) Synthetic RFs and velocity models for station MOOP. a. Synthetic traces computed for the thickness, h = 1 – 6 km with the fixed P-to-S velocity ratio, *Vp*/*Vs*. b. Synthetics computed for *Vp*/*Vs* = 1.8 – 2.3 with the fixed h.

Supp_Figure11.eps (Figure 11) Synthetic RFs and velocity models for station HOPE. a. Synthetic traces computed for the thickness, h = 1 – 6 km with the fixed P-to-S velocity ratio, *Vp*/*Vs*. b. Synthetics computed for *Vp*/*Vs* = 1.8 – 2.3 with the fixed h.

Supp_Figure12.eps (Figure 12) Relocated seismicity from BEAAR [Ferris et al., 2003].

Supp_Figure13.eps (Figure 13) Composite dVs/Vs images showing the 450 km transect based on two different reference models. a. Composite dVs/Vs image from the model (Table 1). The 1-D model is based on the results of Rossi et al. [2006] from BEAAR dataset and previously used in the migration [Rondenay et al., 2008; 2010]. b. Composite dVs/Vs image from the model (Table 2). The 1-D model is consistent with the velocity model used in the relocation of local seismicity recorded from the MOOS array [Li et al., 2013].

References

Ferris, A., G. A. Abers, D. H. Christensen, and E. Veenstra (2003), High resolution image of the subducted Pacific (?) plate beneath central Alaska, 50−150 km depth, Earth Planet. Sci. Lett., 214, 575−588, doi:10.1016/S0012-821X(03)00403-5.

Li, J., G. A. Abers, Y. Kim, and D. Christensen (2013), Alaska megathrust 1: Seismicity 43 years after the great 1964 Alaska megathrust earthquake, J. Geophys. Res., 118, 4861-4871, doi:10.1002/jgrb.50358.

Rondenay, S., G. A. Abers, and P. E. van Keken (2008), Seismic imaging of subduction zone metamorphism, Geology, 36, 4, 275−278, doi:10.1130/G24112A.1.

Rondenay, S., L. G. J. Montesi, and G. A. Abers (2010), New geophysical insight into the origin of the Denali volcanic gap, Geophys. J. Int., 182, 613−630, doi:10.1111/j.1365-246X.2010.04659.x.

Rossi, G., G. A. Abers, and S. Rondenay (2006), Unusual mantle Poisson's ratio, subduction, and crustal structure in central Alaska, J. Geophys. Res., 111, B09311, doi:10.1029/2005JB003956.