Figure 1. The BEAAR network and its setting. Triangles show seismic stations; open: operated 6/99 - 9/01; gray: operated 6/00 - 9/01; black: operated 6/00 - 9/00. Hexagon shows site of 6-element Reindeer array. Black lines: isobaths to Wadati-Benioff zone [Plafker et al., 1994]; white line: cross section projection. Inset shows regional setting.
Figure 2. Events used. Crosses: original catalog locations; filled circles: relocated epicenters; triangles: BEAAR stations; thick gray lines: 50 and 100 km slab isobaths; thin line: location of cross section in Figure 3.
Figure 3. Cross-section of hypocenters relocated using BEAAR arrival times. Crosses: original catalog locations; filled circles: relocated epicenters. Cross section located on Figure 2.
Figure 4: Spectral fitting example with S waveforms. (a) S waves at a northern station (NNA); (b) at a northern station (PVW) from an event 110 km deep. Δ shows distance to stations. (c) and (d) multiaper amplitude spectra of same signals corrected to displacement, (black line) or of noise in 3 s window immediately preceding (gray line). Thin lines show best-fit model following equation (2) for α as labeled. Vertical lines show window being fit on all panels. Note lack of high frequency energy at NNA, typical of wedge paths.
Figure 5. Comparison of $\delta t^*$ to parametric estimates of $t^*_S - t^*_p$. Each symbol represents average measurement for one station over events in one depth range (symbol). Dashed line: 1:1 relationship, gray line: estimated bias in $\delta t^*$ if $P$ and $S$ corner frequencies differ by a factor of 1.5, as expected [Madariaga, 1976]. Similarity of two axes indicates that the parametric method accounts for source effects adequately.
Figure 6. Variance of misfit to spectra summed over data set, as a function of frequency-dependence parameter $\alpha$, normalized to minimum variance value for phases as shown. Np and Ns give number of records used for $P$ and $S$, respectively.
Figure 7. Variations in path-averaged $Q$ with frequency for the mantle wedge ($Q_{av}$, Table 1), for varying $\alpha$. $S$ waves (thick lines) all give similar $Q$ near $f_R=10$ Hz for any $\alpha$, while $P$ waves (thin lines) give same values near $f_R=15$ Hz. The maximum frequencies sampled ($f_{max}$, Table 1) lie near $f_R$, indicating that the greatest sensitivity to $Q$ lies at the highest frequencies used.
Figure 8. Path-averaged $Q_{av}$ for $S$, from events greater than 85 km deep north of 63°N. Rays projected onto cross-section illustrated on Fig. 1, and shaded according to Q, ($\alpha = 0.27$). Topography, top, exaggerated 10 times. Solid triangles: stations; open symbols: relocated events, squares if used in inversions.
Figure 9. Grid used for $1/Q$ inversions, showing constant-$Q$ blocks, for all depths except the near-surface. Triangles: stations; thick gray lines: 50 and 100 km slab isobaths.
so far changed top 2, not bottom ones...

Figure 10. Results of tomographic inversion, in cross section shown on Fig. 1. (A) $1000/Q_S$. (B) $1000/Q_P$ with no constraints. (C) $1000/Q_P$ constrained so that $1000/Q_K$ is nonnegative. (D) Resulting bulk-modulus attenuation $1000/Q_K$, from equation 1. Circles: events; triangles: stations projected onto cross-section. Elevations and topography exaggerated 10 times. White corresponds to a priori model, $1000/Q = 1.67 (Q = 600)$. 
Figure 11. Formal resolution and error estimates from inversions, for cross-section shown in Fig. 10. Left panels show diagonals of resolution matrix. Right panels show full a posteriori uncertainty in units of 1000/Q. \( Q_{Pu} \): Unconstrained P-wave inversion; \( Q_{Pc} \): P-wave inversion constrained so \( Q_k \) is nonnegative; \( Q_S \): S-wave inversion.
Figure 12. Numerical resolution tests. (a) Checkerboard resolution test. Starting checkerboard has 20 km blocks in 2D, with 1000/Q alternating between the a priori value, 1.7, and 10. Note good recovery throughout region. (b) High-attenuation mantle wedge test. Attenuation measurements generated 1000/Q = 10 in wedge, bound by white line, and 1.7 elsewhere. Both tests use same rays and uncertainties as actual Qs result. Circles: events; triangles: stations. Blocks labeled with 1000/Q, if resolution diagonals exceed 0.01 (only within wedge for (b)). Same cross section as Figure 10. For well-resolved blocks, amplitude recovery is 69-87%.
Figure 13. Minimum-parameter inversion for 1000/QS. Format same as Fig. 10. Formal errors are 2-σ.
Figure 14. Cartoon illustrating main Q regimes. DF: Denali Fault trace.
Figure 15. Attenuation ratio for bulk modulus to shear modulus, from division of images in Fig. 10. In mantle wedge, bulk modulus attenuation is negligible, while bulk attenuation is significant in crust and descending plate.
Figure 16. Comparison of observed $Q_S$ in subarc mantle (Table 2) with predicted $T$ for dry mantle. Observations from NE Japan [Takanami et al., 2000], Andes [Myers et al., 1998], Tonga/Lau [Roth et al., 1999], or this study (Alaska; $\alpha=0.27$). Horizontal box width denotes frequencies sampled. All except Alaska assume $\alpha=0$, so likely reflect $Q_S$ at the high end of the frequency range sampled (darkest shading). Alaska wedge appears ~100°C cooler than Andes or NE Japan. Predictions from calibration of Jackson et al. [2002] for 1 mm grain size, adjusted to 2.5 GPa (80 km depth) as described in text. Increasing grain size to 10 mm increases predictions by 100°C, ignoring activation volume decreases predictions 130°C. Dashed line shows typical error in absolute temperature for 1300°C; relative errors are much smaller. Abundant H$_2$O would lower actual temperatures [Karato, 2003].