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Heterogeneous zones characteristic of the crust and upper mantle

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Heterogeneous zones characteristic of the continental crust and upper mantle are found at different well-defined depth levels based on interpretation of high-frequency controlled-source seismic data. Our sources of information are from different regions: the Peaceful Nuclear Explosion seismic data sets from Russia; data from the North American Early Rise experiment; the FENNOLORA experiment in Scandinavia; and reflection data collected in NW Europe. We document pronounced seismic scattering from three heterogeneous zones: The lower crust from ˜20 km to ˜40 km depth, a ˜80 km thick low-velocity zone below ˜100 km depth, and the 320-460 km depth interval around the top of the mantle transition zone. We represent the heterogeneous layers by random fluctuations of the elastic parameters and Q-values. The spatial (horizontal and vertical) correlation lengths and the standard deviation of the fluctuations are constrained by comparison of observed and calculated seismic sections. The lower crustal heterogeneity causes a coda to the upper mantle arrivals at all recorded frequencies. This coda is a prominent feature for whispering-gallery phases, which travel as multiply reflected refractions below the Moho to large offsets. The heterogeneous mantle low-velocity zone causes a scattered coda trailing the first arrivals in the 800-1400 km offset range. The best fit to the observations along profile Kraton in Siberia is obtained by an 80 km thick zone below 100 km depth, represented by fluctuations with spatial correlation lengths of 5-10 km (horizontally) and 3-5 km (vertically). Scattered arrivals, which trail the reflection from the ’410’ discontinuity and a reflection from a shallower depth of 320 km, constrain the heterogeneity around the top of the transition zone. This heterogeneity is modelled by fluctuations with correlation lengths on the order of 20-40 km by 5-10 km. The heterogeneous zones are most likely global features for the continental crust-mantle system. We suggest that the characteristics of these zones should be considered when defining seismic reference models.