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Delamination and ultra-deep subduction of continental crust: constraints from elastic wave velocity and density measurement in ultrahigh-pressure metamorphic rocks

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The density-driven sinking of ultrahigh-pressure (UHP) eclogite facies rocks is invoked as a possible mechanism to illustrate aspects of the crust-mantle interaction processes. We have collected a total of 33 samples, including 22 eclogites, from Dabie Ultrahigh-pressure (UHP) metamorphic belts in eastern China. Compressional (Vp) and shear wave (Vs) velocities in three mutually perpendicular directions in these samples under hydrostatic pressures of up to 1.0 GPa were measured. At 1.0 GPa, Vp (7.5-8.4 km/s), Vs (4.2-4.8 km/s), and densities (3.2-3.6 g/cm^3) of the UHP eclogites are higher than those of UHP orthopyroxenite (7.3-7.5 km/s, 4.1-4.3 km/s, 3.2-3.3 g/cm^3, respectively) and HP eclogites (7.1-7.9 km/s, 4.0-4.5 km/s, 3.1-3.5 g/cm^3, respectively). A kyanite rock shows extremely high velocities and density (9.37 km/s, 5.437 km/s, 3.581 g/cm^3, respectively). The eclogites show Vp- and Vs-anisotropy variation by up to 9.70% and 9.17 %, respectively. Poisson's ratio (σ) ranges from 0.218 to 0.278 (mean 0.255) in eclogites, 0.281-0.298 in granulites, and 0.248 to 0.255 in amphibolites. σ in serpentite (0.341) and marble (0.321) are higher than others rock types. The elastic moduli K, G, E of the kyanite sample were obtained as 163 GPa, 102 GPa, and 253 GPa, respectively. Vp, Vs, and density of four representative UHP metamorphic rocks (two from this work and two from the literature), for the first time to our knowledge, were extrapolated to mantle depth (25 GPa) with simultaneous temperature based on present data, and compared with the one dimension mantle velocity and density model. The comparison shows that Vp, Vs, and density in eclogite, kyanite, and garnetite are significantly greater than that of the upper mantle, with the deference up to ΔVp>1-2 km/s, ΔVs>1-3 km/s, and $\Delta\rho$ >0.3-0.4 gcm^{-3}, respectively. This result favors the density-induced delamination model and provides evidence for distinguishing subducted high velocity materials in the upper mantle by seismic tomography. Such ultra-deep subduction and delamination processes have been recognized by seismic tomography and geochemical tracing in postcollisional magmatic rocks from the Dabie region.