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Mapping mantle flow with PP and SS precursors? - Effects of reaction kinetics on the 660 km discontinuity

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Kinetics of the mantle transition zone phase transitions/mineral reactions may give insights into the density structure and rheology of subducting slabs or mantle plume regions. The effect of kinetics in mantle up- and downwellings on the seismic structure has not been investigated in detail and would add further constraints on mantle dynamics. In this study, we investigate whether and how the effects of reaction kinetics can be resolved with PP and SS precursors. PP or SS precursors are underside reflections of P- or S-waves off the discontinuities, halfway between the source and the receivers. Calculating equilibrium mineral phase assemblages for a pressure-temperature grid for pyrolite and isentropic geotherms, we extract depth profiles of density, P wave and S wave velocity. We use data from kinetic experiments of the reaction of ringwoodite to perovskite and magnesiowuestite and combine them with equilibrium solutions to obtain the seismic structure of kinetically inhibited mineral reactions. From the profiles of density, P wave and S wave velocity, we calculate 1D synthetic seismograms for a range of dominant frequencies. We analyse the frequency dependence of the amplitudes of reflected waves. In order to investigate whether laterally varying fine-scale structures such as kinetically inhibited mineral reactions can be imaged with seismic waves, we calculate synthetic seismograms with an axisymmetric finite-difference code for global P-SV wave propagation. We apply array seismic methods (e.g. vespagrams and migration) and investigate the short period response of the seismic wavefield on deflections of the 660 km discontinuity. Comparing the results from the mineral physics' calculations and from the wave propagation modelling allows us to constrain the lateral seismic resolution of the 660 km discontinuity in mantle up- and downwellings and to map mantle flow with seismic underside reflections on regional and global scales.