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Seismic implications of the kinetics of the reaction perovskite + ferropericlase = ringwoodite

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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. Here we study whether and how the effects of reaction kinetics can be resolved with PP and SS precursors in mantle upwellings. PP or SS precursors are underside reflections of P- or S-waves off the discontinuities, halfway between the source and the receivers. We use data from kinetic experiments of the reaction of perovskite and ferropericlase to ringwoodite and combine them with thermodynamic calculations of phase assemblages to obtain the seismic structure of kinetically inhibited mineral assemblages. The kinetic data show sensitivity to grain size and upwelling rate. 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 and traveltime residuals of the reflected waves. The synthetic modelling shows that kinetic inhibition of the backward reaction of ringwoodite, i.e. the recombination of perovskite + ferropericlase to ringwoodite, affects the amplitudes of PP and SS underside reflections, showing larger amplitudes for shorter periods due to the finite depth interval where the kinetic inhibition occurs. Thus the frequency dependency of PP and SS precursor amplitudes can be a probe to investigate regions of mantle upwellings and to further constrain grain size in the mantle.