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Exploring the range of 3D thermo-chemical variations possible in the Earth's lower mantle

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We have determined a suite of thermo-elastic parameters from the MgO-FeO-SiO_2-Al_2O_3-CaO system from recent experiments that are consistent with the 1D seismic structure of the Earth. Using the sensitivities of temperature and chemistry to seismic shear and compressional velocity and density derived from these thermo-elastic parameters, we use a tomographic inversion to solve for the changes in temperature, mole fraction of perovskite, and mole fraction of iron in the lower mantle. The data include a large compilation of long-period travel times of S and P phases as well as normal mode splitting measurements which provide excellent depth resolution and good lateral resolution even in the lowermost mantle. The thermo-chemical models show that a majority of the anomalous structure in the lower mantle can be explained by variations in temperature. However, in the central Pacific, compositional variations are likely present in the form of an increase in the mole fraction of iron and perovskite. We also present a range of models of temperature as well as perovskite, iron, and calcium content that fit the seismic data. These thermo-chemical models demonstrate that long-period body wave data can be used not only to indicate, but also to quantify variations in lower mantle temperatures, major element chemistry, and mineralogy.