



A NEW KIND OF TOMOGRAPHY REVEALS COMPOSITIONAL VARIATIONS THROUGHOUT THE MANTLE

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To date, the most compelling evidence for compositional heterogeneity comes from several observations of regions with high ratios of relative S to P velocity heterogeneity and a general anti-correlation between bulk and shear sound speed in the lowermost mantle. No clear picture has yet emerged, since the inferences are clearly study dependent, most likely due to the inherent non-uniqueness of the associated inverse problem. To identify all possible models compatible with seismic data (fundamental mode and overtone phase velocity data and normal mode splitting functions), we employed a full model search technique to the tomographic problem. We used Sambridge's Neighbourhood Algorithm. There is no need to employ ad hoc damping parameters, the algorithm is easy to tune, and most importantly, it converts the solutions into probability density functions for long wavelength models (spherical harmonic degree 2 and 4) of bulk and shear sound speed, density and boundary topography in the mantle. Our distributions clearly favour a negative correlation between bulk and shear sound speed throughout the lower mantle, but positive correlations are not entirely unlikely. We further see that all previously published models are correctly represented by these correlations, indicating that the differences between these inverted models are not supported by the data, but most likely due to different regularizations. More interestingly, the seismic data clearly favour density perturbations in most of the mantle that are uncorrelated or negatively correlated with shear velocity heterogeneity and have amplitudes several times larger than damped seismic inversion usually allow. These high density perturbations (independent of, but fully compatible with gravity data) are at odds with mineral physics extrapolations and geodynamic modelling which assumes that temperature alone causes these variations. However, by allowing chemical heterogeneity and employing recent mineral physics data, we can easily explain our results.

Using appropriate sensitivities for velocity and density to temperature and composition we are able to reproduce our observed probability density functions for bulk and shear sound speed and density in the lowermost mantle with simultaneous variations of temperature ($\pm 150K$), perovskite ($\pm 6\%$) and iron ($\pm 2\%$).