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Lowermost-mantle density and thermochemical structure from recent normal-mode measurements

Constraints on the 3-D density structure of Earth's mantle provide important insights into the nature of seismically observed features, such as the Large Low Shear Velocity Provinces (LLSVPs) in the lower mantle under Africa and the Pacific. The only seismic data directly sensitive to density variations at all depths inside the mantle are long-period normal modes: whole Earth oscillations that are observed after large earthquakes. However, their sensitivity to density is weak compared to the sensitivity to velocity and previous studies have presented conflicting density models of the lower mantle, showing either entirely light or entirely dense LLSVPs. A large number of new normal-mode splitting function measurements has become available since the last density models of the entire mantle were published. Here, we present our new models of 3-D mantle velocity, density and discontinuity topography, obtained from the inversion of these recent normal-mode measurements using a Hamiltonian Monte Carlo algorithm, which also provides us with model uncertainties. We find a large high-density region in the bottom-300 km of both LLSVPs, while the remaining LLSVP material has a lower-than-average density. Our model's partially dense LLSVPs imply that they are at least partially compositionally distinct, as temperature variations alone cannot decorrelate seismic velocity and density. Finally, we perform an additional inversion of our velocity and density models to obtain the thermochemical structure in the lowermost mantle, showing that the LLSVPs are relatively hot and enriched in SiO2 and FeO.

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