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Compositional and Thermal State of the Lower Mantle from Joint 3D Inversion with Seismic tomography and Mineral Elasticity

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The compositional and thermal state of Earth's mantle provides critical constraints on the geophysical and geochemical models of Earth. However, the chemical composition and thermal structure of the lower mantle are still poorly understood. Obtaining the 3D thermal and compositional structure from seismic tomography requires the elasticity data of minerals. By developing an elastic method with computation workload only a tenth of the conventional method, we successfully overcame a fatal obstacle of the study, the absence of the elasticity data of minerals at the pressure and temperature conditions of the lower mantle. With the high-quality elasticity data, now we are able to reliably constrain the 3D compositional and thermal structure of the lower mantle. In this study, we inverted the 3D chemical composition and thermal state of the lower mantle based on seismic tomography and mineral elasticity data by employing a Markov chain Monte Carlo (MCMC) framework. The results provided important insights on the Earth's evolution and dynamics. Besides, the compositional and temperature features of the two large low shear velocity provinces (LLSVPs) are also studied, which provide crucial constraints on their origins.