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Mantle Lithospheric Temperature and Compositional Variations using Xenoliths and Seismic Tomography

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To examine the effect of upper mantle compositional variations on seismic velocities, we exploit the Perple_X thermodynamic solver using the Holland and Powell database, and the mineral physics parameters of Schutt and Lesher (2010), to estimate seismic wave speeds through a wide range of mantle xenoliths. Our database includes peridotitic and eclogitic xenoliths from abyssal, forearc, cratonic, off-cratonic continental, passive margin, ophiolite, and massif settings. Initial results show that, although large compositionally modulated velocity variations occur in each setting, the mean velocities in these geologic regions are almost the same. Thus, we conclude that, on average, different settings have almost no compositional effect of seismic velocity. This finding suggests that seismic velocities vary compositionally over small scales, but that the mean seismic velocity observed on a regional scale is nearly independent of composition.

Then, using these measured velocities, we estimate temperatures at the base of the crust in the U.S., China, and Australia by mapping Pn velocities to temperature. These temperatures are compared to xenolith-derived geotherms to determine spatio-temporal thermal variations in the mantle lithosphere. Our lithospheric temperatures in the U.S. (updated from Schutt et al., 2018) show patterns consistent with recent tectonism, whereas temperatures in Australia and China are more complex and show large variations. Areas that are predicted to be anomalously hot using our Pn conversion are generally consistent with Cenozoic-Recent xenolith locales where geothermometry indicates high temperatures, but these large variations also may be due to instability in derived Pn velocities.

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