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Temperature changes in the Australian and Chinese uppermost mantle with time.

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Temperature change in the mantle through time can give insight into time-variations in forces and tectonics. We use seismic tomography to estimate the temperature of the uppermost mantle and compare this to xenolith and xenocryst-derived geotherms to infer temperature change with time. This is done in two locations with multiple locations of garnet peridotites: Australia and China.

Xenolith P and T are estimated through a two-pyroxene solvus thermometer and the garnet-orthopyroxene aluminum-exchange barometer (Taylor, 1998; Nickel and Green, 1985). For clinopyroxene xenocrysts, the enstatite-in-clinopyroxene thermometer and the Cr-in-clinopyroxene barometer is used (Nimis and Taylor, 2000; Sudholz et al., 2021).

We use the results of seismic velocity tomography that is most sensitive to the upper mantle. These velocities are then converted to temperature. To do so we take two approaches. In the first approach, we take the whole rock composition for subcrustal lithospheric mantle (SCLM) and run it through Perple_X for a variety of temperatures and depths using the Jennings and Holland database (Jennings and Holland, 2015). This produces mineral mode and mineral endmember variations that are then converted to velocity variations using a best estimate of mantle mineral endmember elastic parameters. Notably, the output shows an increase in the Tschermak's component of pyroxene with temperature. This endmember may have a high bulk modulus, based on mineral physics studies of naturally occurring pyroxenes (Schutt and Lesher, 2006). If this bulk modulus is correct, existing understanding of the effects of temperature on P-wave seismic velocities is wrong, and velocities vary slower with temperature than previous studies have predicted. Since the evidence for a high bulk modulus is equivocal, as a second approach we also take laboratory measurements of the modal proportions at the solidus temperature and assume no metamorphic changes. This provides another mapping of velocity to temperature. In both of these cases we then add in anelastic effects.