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Thermal buoyancy related to exothermic phase change at 410 km depth, a possible origin for upper mantle plume

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Global and regional seismological observations indicate hot up welling plumes limited to the upper mantle in different locations around the earth. Upper mantle plumes are associated with a flat 660 km depth seismic discontinuity and a seismic velocity anomaly, which indicates a thermal anomaly of less than 200K. Although observed and studied extensively, there is no clear explanation for the origin of upper mantle plumes. Here we use a 2D plane-strain thermo-mechanical Finite Element model to show that the key to explaining shallow upper mantle plumes is thermal buoyancy resulting from upward passive flow through the 410 km depth exothermic olivine-spinel phase change boundary. Upward passive flow may result from continental extension or be associated with divergent motion at mid ocean ridges. We have studied the sensitivity of model results to the Clapeyron slope, amount of density jump and varying spreading rate. The result of modelled lateral thermal anomalies ranging from 90-120 K depending on Clapeyron slope and density jump are consistent with seismic velocity contrasts inferred from regional and global tomographic studies. Further, we have explored the possible effect of 660 km depth endothermic phase change and 520 km depth exothermic phase change in the model results.