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Highlighting seismic velocity variations in cratonic lithosphere from the consistent analysis of surface wave dispersion.

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One robust approach in assessing the variations in structure beneath different cratonic regions is through the comparison of the dispersion characteristics measured at a seismic array, or as part of a broader tomographic study. Subsequently, a consistent analysis technique can be used to model (inverse methods or forward modelling) the velocity structure that provides a good level of fit to these dispersion data. In contrast to direct comparison of pre-existing velocity models this approach minimises the effect that different parameterisations or regularisations will have on the velocity variation with depth. However, for inverse modelling a significant challenge in interpreting the resulting variations remains the dependence on the choice of starting model.

We assess the variations in lithospheric structure beneath Fennoscandia, southern Africa, Slave Craton (Canada) and the Yilgarn Craton (Australia), by inverting the dispersion characteristics with respect to a starting model that is derived from experimental mineral physics. The combination of Litmod and Perplex are used to define an a priori velocity structure for the cratons assuming a slightly depleted mantle composition and a steady state geotherm with a thermally defined base of the lithosphere at 200km depth. One advantage in using this style of starting model, as opposed to a seismologically determined reference (e.g. PREM or ak135), is that the perturbations in velocity can be more meaningfully interpreted. Variations from the starting model now clearly indicate regions where the thermal, or compositional, structures are more complicated than our initial a priori choice.

Our investigations focus particularly on the uppermost mantle - from the Moho to 100km depth. At this depth, many seismic models beneath cratons indicate slower velocities than would be expected. By damping back towards our physically derived a priori starting model, we significantly increase confidence that the slower velocities are a robust feature, rather than an artifact of the parameterisation and a poor choice of reference model. The most plausible explanation of these low velocities is a distinctly different composition in this region. We would therefore anticipate that with sufficient data, mantle discontinuities should also be observed in receiver functions, which would clearly indicate a compositional layering within the lithospheric mantle.