Upper Mantle Structure of the Slave Craton from Teleseismic Body-Wave Tomography

Straub, K.M., S. Rondenay, and D. Snyder

Cratons form the core of the majority of Earths continents and offer a unique window into the evolution of continents and plate tectonics over geological time. The dynamics that led to the evolution and stabilization of cratons over one billion years ago, however, remains poorly understood. The Archean Slave province, located in the NW Canadian Shield, is an ideal site to study the formation of cratons due to its high degree of preservation and evidence that its lithosphere possesses a distinct stratification resulting from cratonic assembly. In addition, numerous geochemical and petrological analyses have been performed over the past 15 years on xenoliths sampling the Slaves lithosphere, yielding important constraints on mantle state and composition. In this study, we investigate upper mantle velocities beneath the Slave craton using body-wave travel time tomography. The region is well situated relative to global seismicity, making it an ideal craton to study using seismic tomography. Velocity models are generated by inversion of body-wave travel-time delays for isotropic slowness perturbations with respect to the iasp91 radial Earth model. Our primary data set consists of 2345 teleseismic travel-times from 204 events recorded over three years (2000-2003) by the Northwest Territories component of the POLARIS broadband seismic network. Results from the inversion of these data agree with those from a reconnaissance study conducted by Bank et al [2000], but add greater resolution across the Lac de Gras kimberlite field. To increase the overall resolution, a more comprehensive inversion is performed on the combined POLARIS and reconnaissance data sets. Preliminary results from this inversion suggest a >1.0\% lateral velocity contrast that coincides with the western edge of the craton, pointing to differences in lithospheric evolution of the Slave province and the surrounding Proterozoic terranes. The model suggests two additional features of interest: first, a lateral SW-NE trend in alternating positive/negative velocity regions, whose outlines coincide with those of an ultra-depleted mantle region previously inferred from geochemical, petrological and MT studies; second, a low velocity anomaly centered to the south of the Lac de Gras kimberlite field and observed between 50-150 km depth. This latter anomaly has a radius of ~50 km, it exhibits a 2.8\% slowness contrast with respect to the surrounding mantle, and may represent post-stabilization alteration of the cratonic lithosphere by processes responsible for kimberlite magmatism.