Receiver Function Analysis of Crustal and Upper Mantle Stratigraphy Across the Western Superior Province

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Summary

The Superior Province is the Earth's largest Archean craton. Its western portion in Canada represents the nucleus of the North American continent, originating from widespread crustal accretion at about 2.6 Ga. The western Superior has a lineated structure with well-preserved supracrustal rock sequences, mineral resources, and greenstone-granite terranes. Its strong east-west tectonic fabric is most commonly attributed to the formation and accretion of island arcs and accretionary prisms. However, this plate tectonic hypothesis has been disputed over the years because of heat loss considerations, and the absence of plate tectonic indicators such as blueschists, ophiolites, and mélanges in the area.

We are in the process of examining the stratigraphy, velocity structure and thickness of the crust and upper-mantle beneath the western Superior Province of the Canadian Shield, through the analysis of seismic discontinuities on the radial and transverse components of P-wave receiver functions. The data used are from POLARIS/FedNor and CNSN earthquake-recording stations across western Ontario. The events used occurred between 2003 and 2008, have a magnitude of 5.5 or greater, and occurred at depths greater than 70 km. Receiver functions were calculated using a panel deconvolution approach (using inter-trace regularization constraints) to improve the signal-to-noise ratio.

The receiver function data show indications of crustal and mantle layering. Stations east of the Nipigon embayment reveal a complicated and layered mantle, whereas west of the embayment reveals a more uniform mantle. These observations agree well with results from recent shear wave splitting studies, which indicate strong splits to the west but weaker, less coherent splits to the east.

Other observations to date include: crustal discontinuities which lose continuity laterally, possibly due to subducting structures and/or regions of velocity gradients, and lobes of opposite polarities on the radial and transverse components of the receiver functions, which are indicative of seismic anisotropy or dipping features. Modeling of these data for dip and anisotropy is in progress.

The results obtained from this study will be integrated with previous receiver function studies, tomographic models, and LITHOPROBE reflection and refraction surveys across the western Superior, and compared to tectonic theories of continental root formation due to imbrication of subducted Archean material, underplating, and accretion of island arcs in that region.