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The Moho beneath the Canadian Shield

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The 3.9-0.9 Ga Canadian Shield and adjacent platform regions represent a 'type' craton, with the world's most extensive exposures of Archean nucleui, Paleoproterozic mobile belts and continent-continent collision zones. Many important processes of continental crust formation and stablization are expressed in both the rock and geophysical record of the Shield. The recent conclusion of Canada's LITHOPROBE program and inception of new programs of passive geophysical observation, such as POLARIS, provide a unique and useful vantage point to review our state of knowledge of the Moho beneath the Canadian Shield, and cratons in general.

LITHOPROBE controlled-source seismic experiments carried out between 1984 and 2001 reveal that the so-called reflection Moho (the base of a zone of subhorizontal reflectivity in the lower crust) is an almost universally present marker beneath the Shield, as is the case for continental crust of much younger age. In most cases the reflection Moho coincides with the seismic Moho defined from refraction studies (the depth at which P-wave velocity surpasses 7.8 km/s). Crustal thickness in the Shield (35-50 km) is slightly greater than the global average, but not exceptional. Thus, the seismic expression of the Moho beneath the Shield is in many ways typical of other continental regions.

Based on LITHOPROBE seismic studies, several other important characteristics of the Moho beneath the Canadian Shield emerge. There are sometimes tantalizing (but controversial) hints that lower-crustal reflections are listric into the Moho, suggesting that it served as a rheological boundary during deformation. Often, however, significant topographic relief is preserved including localized pop-up and keel-like structures with wavelengths of 50-200 km and amplitudes of more than 10 km. The fine structure of the lower crust, Moho and uppermost mantle often preserves tectonic elements that can be correlated to surface features. In rare instances, distinct ages of reflections or

layers are evident and a self-consistent chronology of events can be inferred. These observations, coupled with the inferred Precambrian age of imaged structures, imply that the Shield Moho formed under ductile conditions, but was rapidly quenched and has since remained ‘frozen’ over geologic time scales.

Wide-angle reflection/refraction experiments show that the Moho is sometimes better approximated as a gradual transition rather than a discrete boundary. The lowermost crust, particularly in some Archean regions (e.g., the western Superior Province and the Wyoming Province), contains a thick (10-20 km) high-velocity (> 7.5 km/s) layer that adds substantially to the overall thickness of the crust. Teleseismic *Pn* arrivals similar to those found in Russia and elsewhere have been observed in every case where offsets are sufficiently large (> 500 km), indicating that this sub-Moho guided phases conveys information that is generally applicable to continental areas.

Other types of geophysical observations help us to constrain the composition and physical state of the Moho. Comparison of gravity and crustal thickness maps shows that not all large deflections of the Moho produce gravity anomalies. This appears to confirm recent models that the density contrast between the lowermost crust and upper mantle diminishes with time as a result of metamorphic transformation of lower-crustal rocks to eclogite facies. Heat-flow observations show that the heat flux from the mantle beneath most of the Shield is very low, consistent with the presence of a cold, refractory mantle root and consistent with the preservation of ‘quenched’ Moho structures. In most parts of the Shield the crust exhibits typical layering including a conductive lower crust, but in parts of the Shield (Slave Province) the electrical Moho can be detected.