As sharp as you can measure: constraint on the vertical extent of the crust-mantle boundary beneath North American craton (Superior Province, Quebec).

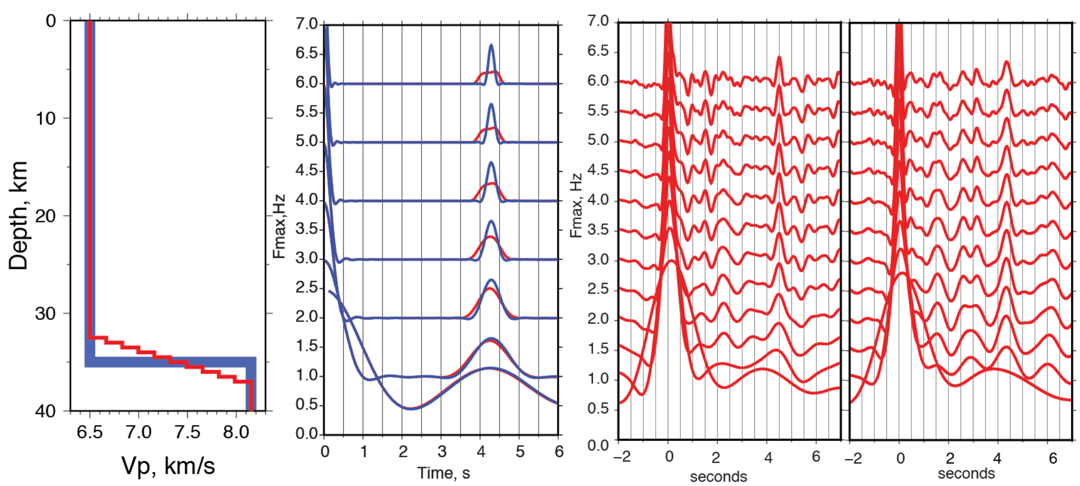
Vadim Levin, Andrea Servali, Jill van Tongeren
Department of Earth and Planetary Sciences, Rutgers University, New Jersey

We investigate the vertical extent of the transition from the crust to the mantle (i.e. the sharpness of the Moho) using observations of mode-converted shear waves within the coda of first-arriving P waves from distant earthquakes. Using receiver function analysis technique we isolate these waves and examine their pulse shapes. The pulse shape of the P-to-S converted wave in the receiver function time series offers a constraint on the sharpness of the boundary where it originates. We use an inverse of the widely accepted ¼ wavelength rule and assume that a change in seismic properties over a certain vertical distance will appear "sharp" (i.e. instantaneous with respect to depth) to a wave that is 4 times longer than this distance. Consequently, the shortest wave that detects the seismic boundary will provide a measure of its vertical extent.

From massive data sets (100s of records per site) accumulated at long-running seismic stations in the Superior province of Quebec we select groups of nearby earthquake sources and process their records together to form common receiver function time series. We construct receiver function time series with different frequency content, and compare resulting pulse shapes of the P-to-S converted wave from the Moho with timeseries predicted for a variety of velocity profiles across the crust-mantle boundary.

At a number of sites in 2.7 Ga old Superior Province receiver function time series with frequencies up to 3 Hz contain clear P-to-S converted waves from the Moho, implying a vertical extent of ~0.3 km for the change in velocities from the crustal to the mantle. We note that the frequency content of data we use is the limiting factor, and the velocity contrast may be sharper.

Timing of our Moho converted waves (~4.5 s delay relative to parent P) implies crustal thickness on the order of 35-37 km, below the global average for continents. We interpret the combination of this modest crustal thickness with an extremely abrupt change in properties at the bottom of the crust as evidence for an episode of lower crust delamination that took place prior to the final stabilization of the Superior Province.



Two left panels: velocity profiles (Vp/Vs=1.75) and expected receiver function time series, coordinated by color. Broader vertical gradient leads to a smaller and wider P-to-S converted wave. Two right panels show receiver function time series from the Superior Province (left – Weminji, right – Matagami).

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