Supplementary Material

Methods explanation:

**Backprojection:**

The backprojection method uses a simple layered velocity model for the conversion from receiver function time to depth. Using Snell’s law and the ray parameter, the initial arrival angle and ray path can be estimated. Distance from the station is also corrected for the backazimuth of the incoming energy when the ray is projected onto the line connecting the first and last stations in the array.

**CCP:**

The CCP (common conversion point) imaging approach starts with the backprojection method and determines the depth and distance of conversion at an interface where depth estimates exist (e.g., the Moho). The length of the array is divided into distance bins. In this case, bin spacing is equal to station spacing. All rays that have a conversion point in a given distance bin are stacked and the amplitude of the resulting stack is plotted vertically at the location of the bin with a width equal to the bin station. A small amount of smoothing is applied to ensure a smooth transition between bins. Thus this is different from backprojection which is a stack of all rays passing through each point in depth and distance. At a given distance bin there is a single stack of all receiver functions that pass through at the Moho depth. This results in more smoothing and averaging than the backprojection method.

**RF migration:**
This method uses a simpler velocity half-space model because it uses a more complicated inversion technique that involves travel-time calculations for every possible scattering point. The inversion and migration technique are described in Bostock et al, 2001 and Kim et al, 2010.

From Kim et al. 2010: “Here, we migrate the P-to-S converted phases (Pds, conversion from the top of the oceanic crust to the base of the continental crust, and Pms, conversion from the mantle to the bottom of the oceanic crust) using a Kirchoff-style migration, which characterizes the output model as a grid of point scatterers. We assume that teleseismic P waves are arriving sufficiently far away that they can be approximated by plane waves. Traveltimes for the P-to-S converted waves are calculated by assuming that the incident plane P wave converts to S wave energy at every possible scattering point. . . After determining the traveltimes of the converted wavefields at the scattering point, corresponding amplitudes are stacked to form an image. . . We use a simple layer velocity model to compute traveltimes for the converted wave. . . Several velocity sensitivity tests were performed to find that the energy is sharply focused when the average crustal P wave velocity is 6.3 km/s and S wave velocity is 3.6 km/s.”


Appendix A

This section contains supplementary material and figures to provide additional details and clarification of the methods and results discussed in the paper.

A1. Sample receiver functions showing observations of a mid-crustal structure at various points of the array. Each example shows multiple events for a single station shown on the map as a pink circle. The mid-crustal structure at around 5 seconds (~40 km depth) is denoted as MC and the signal from the Moho is also shown.
A Gentle curve model

B Linear slab model

C Slab break model
A2. Different models for Line 2, the transition from steep to shallow subduction. Three models were tested with finite difference modeling to produce synthetic receiver functions (see Figure 3 for model used for Line 2). A) Gently curving model comparable to Figure 3 and resultant synthetics, B) Linear slab model and synthetics, C) Steep transition from normal to flat slab subduction (as might be seen if there was a slab break) and corresponding synthetics.
A3. Receiver functions from station PE46 (located near Julicaca) from a NW azimuth.

The main positive impedance arrivals which can be seen are the P wave arrival, a mid-crustal arrival (at~5.6-6 sec) and a Moho signal at~9 sec. The same arrivals are seen consistently for all events regardless of the phase used (P, PP, PKPab, or PKPdf).

However note that strong conversions at horizontal interfaces are not expected for PKP phases. Consequently PKP RF are analyzed separately from P and PP receiver functions.
but all phases are shown here for comparison. The phase used is listed to the right of each trace.
A4. Example of a grid search over H and Vp/Vs where H is the depth to the discontinuity (which in this case is the Moho). The most probable Moho depth and Vp/Vs ratio is determined from the maximum summation of amplitude at the calculated locations of the Moho and multiple arrivals. The bottom figure shows receiver functions for PG05 which were used in the stack to obtain the grid search location shown at the top. Uncertainty is given by the 95% probability contour (black line).

A5. Left: Comparison of radial and transverse receiver functions for station PF37 in Line 2. Right: Not including the dominant P arrival for the radial receiver function, the
maximum amplitude of the radial and transverse receiver functions in the first 10 seconds is found to be approximately comparable for the radial and corresponding transverse RFs. In normal situations, the energy on the transverse component should be significantly less than the radial RFs. That they are comparable for most of the stations looked at on Line 2 is suggestive of possible dipping structure or anisotropy. The top right figure shows the maximum amplitude of the radial (blue) and transverse (red) RFs for PF37 and the bottom right figure shows their ratio as a percentage. The black line shows a linear fit to the data demonstrating that the average is on the order of 100% (1:1).
A6. Transverse receiver functions for station PF42. For many of the stations looked at, there appeared to be a polarity change in the strongest signal observed on the transverse component. According to Savage 1998, observations of 180° periodicity may be indicative of anisotropy with a horizontal symmetry axis while 360° periodicity could indicate a dipping symmetry axis or dipping structure. As seen here, directions 180° apart (e.g. NW and SE) display opposite polarity at the time of the largest signal (~2 sec). The circle shows the directions that the numbered traces were taken from. Receiver functions were stacked in the bins/directions shown.

A7A-C. Further examples of transverse receiver functions from Line 2. Note the strong signals occurring before 5 seconds (generally at 2-3 seconds). In most of the cases the polarity was observed to demonstrate 180° periodicity. A thin yellow line in the figures shows visual estimations of the possible symmetry axis. (a) Transverse RFs for stations PF12 and PF13. Stations are numbered from 1 to 50 approximately every 6 km running from Juliaca to Cusco. (b) Transverse RFs for stations PF23 and 24 near the center of the array. (c) Transverse RFs for stations PF29 and PF31.