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Receiver Function Images of the Western U.S. Lithosphere Using Transportable Array Data

By Meghan S. Miller, University of Southern California and Alan Levander, Rice University – Summer 2009.

The tectonically active western United States can be divided broadly into several physiographic/tectonic provinces. Although most provinces have a strong pre-Cambrian and Paleozoic tectonic imprint, all have been greatly modified by and owe their current structure to the large-scale Mesozoic-Cenozoic interactions of the Farallon and Pacific plates with the North American plate. The deep structure of the continental lithosphere beneath each province and its response to changes in tectonic motions are not clearly understood. The USArray Transportable Array data uniformly sample the tectonic provinces in the western US with the large number of recorded teleseismic earthquakes allowing construction of lithosphere-scale structural images.

Using Transportable Array teleseismic data we have made common conversion point (CCP) stacked PdS and SdP receiver function image volumes to determine, in more detail and higher resolution than previously obtained, the crustal thickness and the depth to the lithosphere-asthenosphere boundary (LAB) beneath the western US.

Receiver functions can be made with two types of scattered waves: P converted to S at an interface at depth d (PdS), and, similarly, S converted to P (SdP). Receiver functions isolate converted waves resulting from seismic velocity and density layering beneath a station that appear in the P coda for PdS, or preceding the S arrival for SdP (*Langston*, 1977; *Reading et al.*, 2003; *Vinnik*, 1977). Individual receiver functions can be converted to depth and laterally "migrated" to their conversion point using a reference velocity model, with redundant signals stacked for signal enhancement. The use of both PdS and SdP allows for independent models of the same area and provides different frequency bands and ray paths to image crust and upper mantle structure.

Our PdS wave volume contains ~11,000 receiver functions from 70 earthquakes and our SdP wave volume ~5,000 receiver functions from 45 earthquakes. At present the imaging volumes extend from the Pacific continental margin to ~108°W and from Mexico to Canada to approximately 200 km depth. S-wave receiver functions were depth converted, spatially repositioned, and common conversion point stacked using a 1D reference model based on MC35 and an average Western U.S. crust. The travel times for PdS image volumes were computed using linear tomography corrections for 3D velocity models constructed from Crust2.0 (*Bassin et* *al.*, 2000) and the mantle model of van der Lee and Fredericksen (2005) before converting to depth.

The current images sample the lithosphere and asthenosphere beneath most tectonic provinces of the western US: the Pacific-North American plate boundary (PPB), Sierra Nevada (SN), Cascadia subduction zone (CAS), Snake River Plain (SRP), Basin and Range (BR), and Colorado Plateau (CP). Both the P and S wave receiver function stacks show a nearly continuous, although variable strength, Moho, identified as a positive (red) polarity event (Figure 1). The P and S-wave receiver functions also image deeper features, such as the LAB. The LAB is a negative polarity feature (blue) with significant topographic variation between tectonic provinces and unlike the Moho cannot be described as a single surface (Figure 1).

In the BR, CP, and Transverse Range provinces the PdS and SdP estimates for both the LAB and the Moho depths are in good agreement (Figure 1). Figure 2 is a crustal thickness map interpreted from the PdS receiver functions. The map illustrates the thin crust of the coastal terranes of the PPB, thicker crust under much of the SN, thin crust in the BR and then rapid crustal thickening beneath parts of the CP.

The Transportable Array is providing a voluminous dataset to study the lithospheric structure beneath the US. As the footprint of the array moves east we plan to produce updated crust and LAB images of the Rocky Mountains, the central plains and craton in the interior, and the eastern US. The crustal thickness and LAB maps and data are available online at http://terra.rice.edu/department/faculty/levander/downloads.

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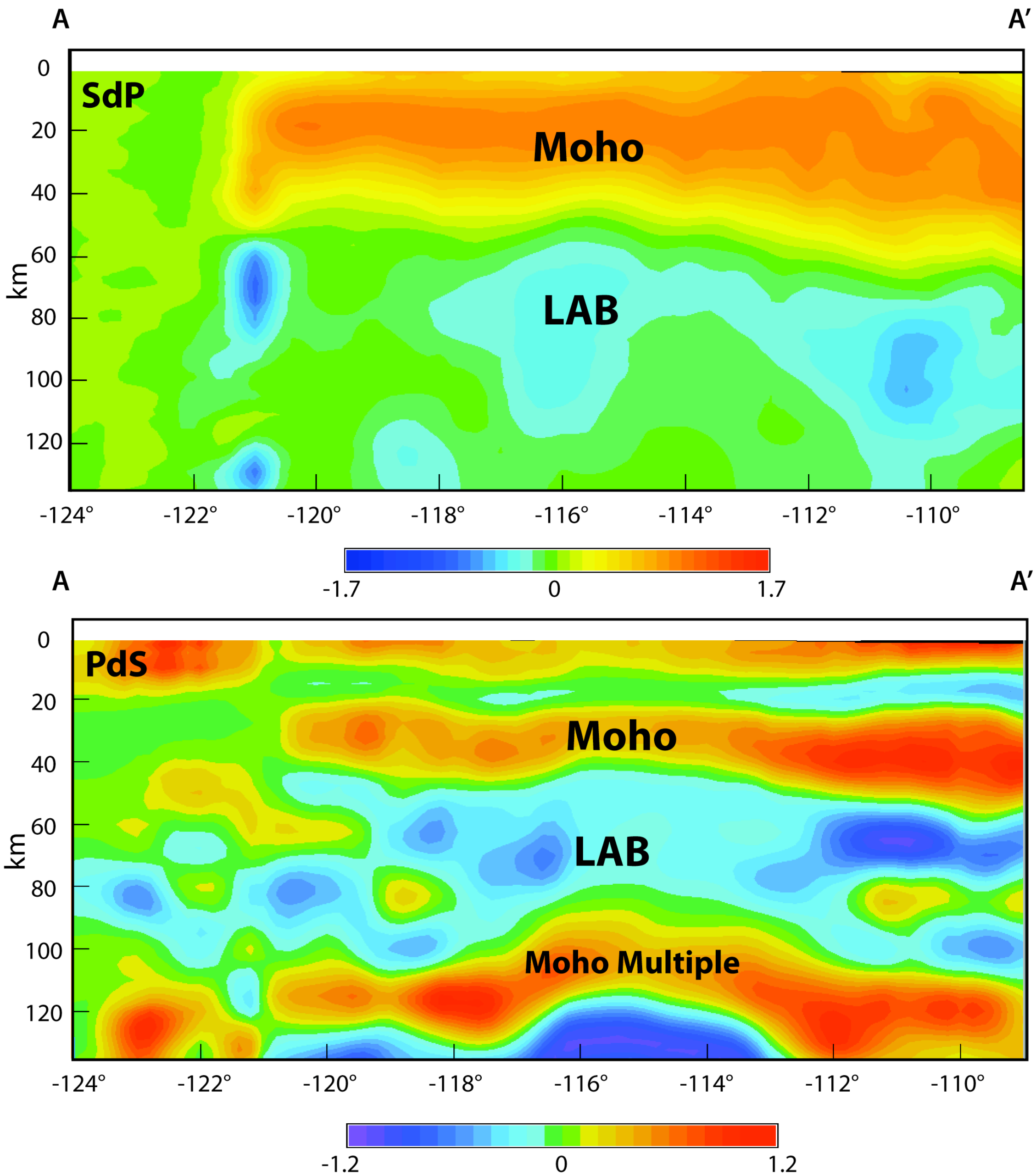

Figure 1: Cross sections through the SdP (top panel) and PdS (bottom panel) volumes along 34.5°N (see Figure 2 for location), which profiles the CP, SBR, and PPB. Note: The red feature in the PdS image at ~100 km depth is a multiple.

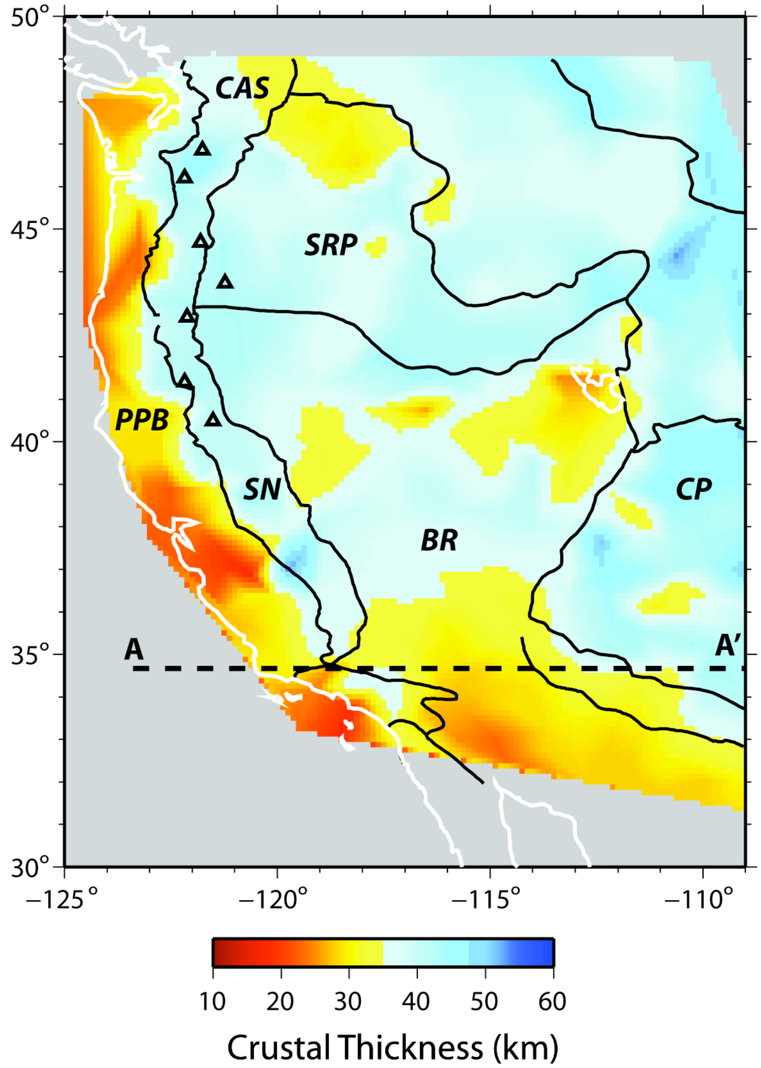

Figure 2: Depth to Moho map based on the PdS receiver function image volume. White lines are coastlines and black lines are the tectonic provinces as defined in text. A-A’ illustrates cross section location in Figure 1.

Glossary:

Common conversion point back-projects receiver functions along the signal's path thus placing signal at the location where it originated. Stacking is adding signals from many observations - earthquakes and seismic stations - for each element of the 3-D volume; stacking increases the strength of the coherent signal resulting in clearer images.

Lithosphere-asthenosphere boundary (LAB) is an important rheological boundary in the Earth. Lithosphere consists of Earth's crust and uppermost mantle and is quite rigid. Lithosphere plates move on top of lower viscosity asthenosphere, which over long-time intervals is flowing. LAB thickness is one measure of tectonic plate thickness.

Moho is the crust mantle boundary, formally known as the Mohorovičić Discontinuity, named for the Croatian scientist who first identified it.

Receiver functions are time series computed from three-component seismograms by deconvolving one trace by another to emphasize signal generated at interfaces (layer boundaries) below a seismic station. For an overview see http://eqseis.geosc.psu.edu/~cammon/HTML/RftnDocs/rftn01.html. For a comparison of Moho-depth results for USArray sites visit the EarthScope Automated Receiver Survey (http://ears.seis.sc.edu//).

Teleseismic data are seismograms recorded at stations more than 3000 km from an earthquake source. The seismic waves traveling through the Earth impinge nearly vertically (less than 20° from vertical) on the recording site.