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Improved LAB estimate: A necessary step in developing the Community Thermal Model for southern California

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Summary

The goal of this work is to image the lithosphere-asthenosphere seismic boundary (LAB) beneath California to improve constraints for estimating the thermal gradients and rheology of the lithosphere as part of the development of the Community Thermal Model (CTM). Thickness of the lithosphere plays a significant role on temperature variations in the lower crust, which in turn affect rheology, lithospheric strength (and hence stress), and horizontal and vertical deformation partitioning.

Our LAB imaging resolves high variations in the lithospheric thickness across California and adjacent regions. We image thin lithosphere beneath the Salton Trough, Inner Borderland, the San Francisco Bay area and further west, southern end of the Great Valley, and beneath the Modoc Plateau and further east. Thickest lithosphere is found beneath western central Nevada, western Transverse Ranges, and northern segment of the Peninsular Ranges.

Previous LAB models include Lekic et al. (2011) in southern California, Ford et al. (2014) in central and northern California, and Reeves et al. (2015) for the Borderland region. This study includes all of California in an effort to produce a cohesive model of unified lithospheric thickness. We improve the image of the LAB beneath California by incorporating time-to-depth migration using 3-D velocity models, including the SCEC CVM, to back-project the energy of *Sp* phases converted at the lithosphere-asthenosphere boundary. The LAB depth map (Figure 4), while broadly similar to previous studies, reveals structural variations as a result of the improved crustal models used for back-projection.

Technical elements of the California LAB imaging

In the following section we summarize some of the technical aspects of our imaging process.

We constructed a high-resolution crust and uppermost mantle 3-D velocity model across California and adjacent regions by integrating the southern California crustal velocity model CVM-S4.26 (Lee et al., 2014) into published results from surface waves studies (Shen and Ritzwoller, 2016). We used this model to extract 1-D station velocities to back-project the receiver functions (RFs) at each station. We have currently utilized data from 225 TA stations (Figure 1). Data from flexible array deployments and other minor arrays are currently being analyzed for incorporation into the model.

Data used in this model were generated by events at epicentral distances from 55° to 85° with magnitudes > 5.8 and depths shallower than 300 km (Figure 2). Data were filtered between 0.02 and 0.5 Hz with a Butterworth bandpass filter. The S phase arrival times were manually picked, and data were cut 80 s before and 20 s after the arrival of the S phase. Waveforms were rotated from Z-N-E into the local ray coordinate system P-SV-SH using the back-azimuth and incidence angle of the incoming ray. *Sp* receiver functions were calculated using the time domain deconvolution method of Ligorria and Ammon (1999). All resulting waveforms were visually inspected and only those with a clear arrival relative to subsequent phases were retained. The model space was parameterized with nodes every 1 km in depth and ~10 km laterally distributed on a 3-D rectangular grid from 0 to 150 km depth across California and the adjacent regions. We used the composite crust and uppermost mantle model (Shen and Ritzwoller 2016 and Lee et al., 2014) to back-project each receiver function amplitude along the ray-path. We used the common conversion point (CCP) stacking method (Zhu et al., 2006) to stack the *Sp* receiver function amplitudes in bins calculated based on the size of the first Fresnel zone at a given depth. We manually picked LAB depths from the stacked volume based on a visual analysis of the amplitude field. Figures 3 and 4 show the number of receiver functions that contribute to each LAB phase node and the resulting LAB depth map. The highest number of RFs, and therefore highest confidence are focused on the central parts of the model.

This work has established a framework for producing high-quality LAB depths across all of California and the adjacent regions. Ongoing and future work focuses on incorporating additional data from flexible arrays and other broadband experiments to improve local resolution in regions of interest. This will increase the level of detail we resolve for the lithospheric thickness to contribute to constraints for the CTM. This work will be presented in a future publication.

References

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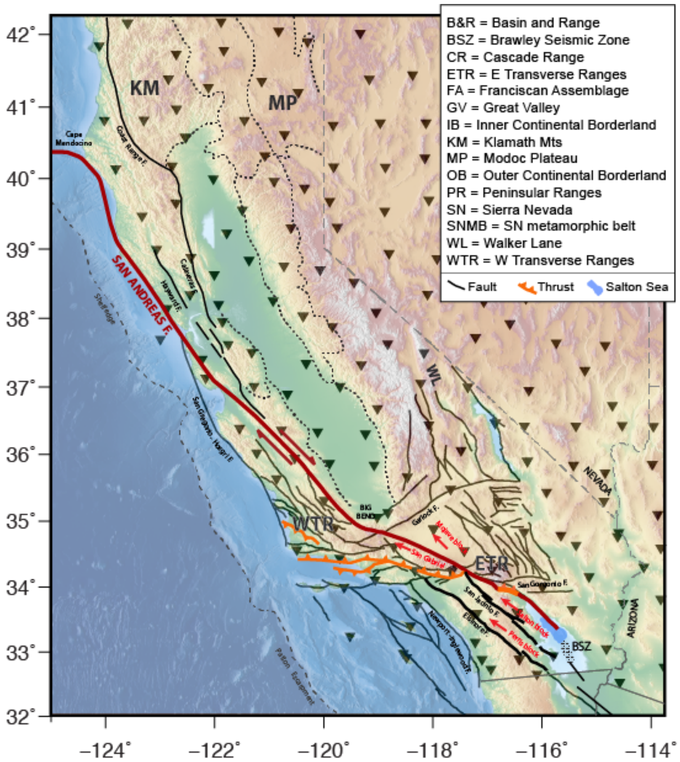

Figure 1. Stations used in this study (black triangles) and major tectonic features. Background colors represent elevation.

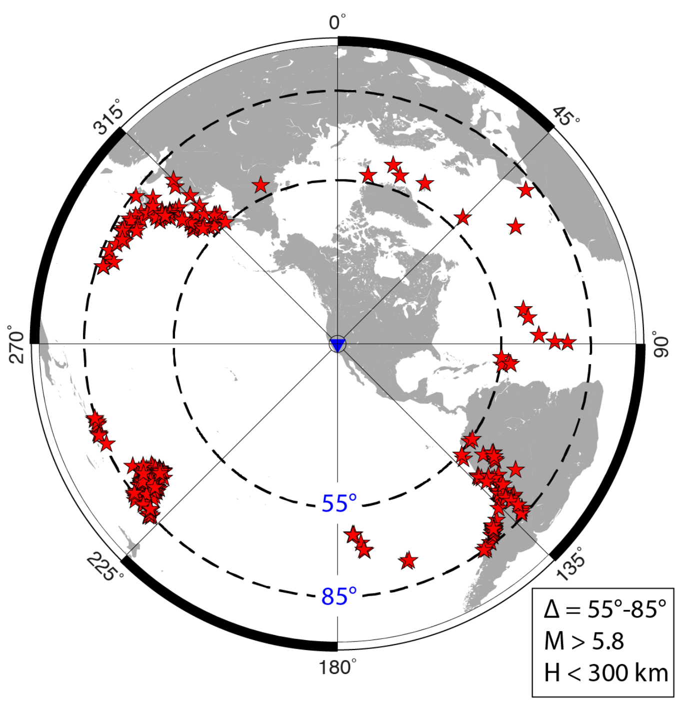

Figure 2. Azimuthal distribution of events (red stars) relative to the center of the model box (inverted blue triangle).

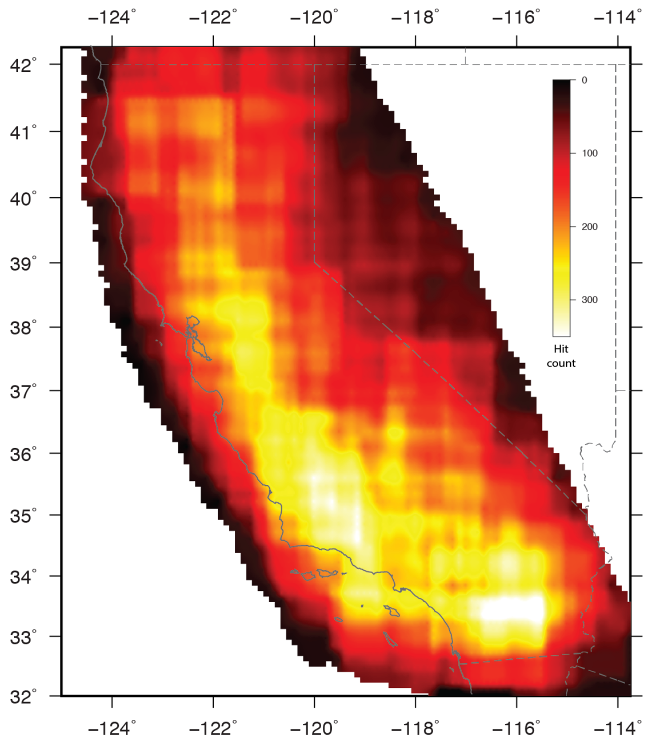

Figure 3. Receiver function count contributing to LAB depth nodes.

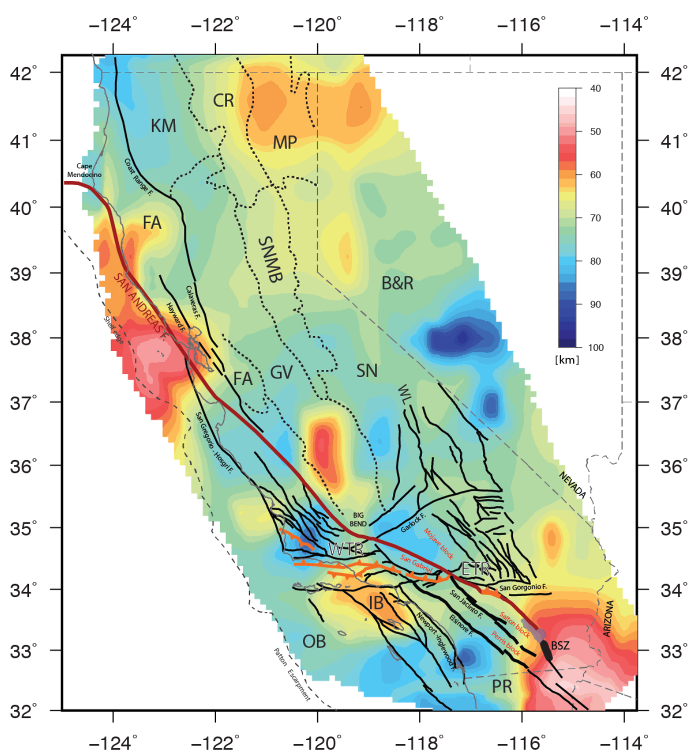

Figure 4. California LAB depth map. Black continuous and dotted lines indicate tectonic features and state boundaries.