Contrasting Lithospheric Signatures Across the Western United States Revealed by Sp Receiver Functions

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The varied history of deformation and magmatism across the western United States presents an ideal setting for exploring the relationship between lithospheric structure and deformation. We use observations of shear-to-compressional wave conversions across velocity interfaces to constrain lithospheric structure; larger velocity gradients produce stronger conversions. Using a newly developed automatic method designed to take advantage of the broadband seismic arrays deployed across the region, and an optimized deconvolution technique based on the extended-time multi-taper method, we map variations in the depth to the seismic Moho, the lithosphere-asthenosphere boundary (LAB) and the mid-lithospheric discontinuity (MLD). We demonstrate that the array-based picking algorithm yields more accurate S-arrival picks, and that this increased accuracy results in more coherent common conversion point (CCP) stacks. Sp CCP stacks obtained using all available data and those obtained using only data from the Transportable Array (TA) are comparable, indicating that the length of deployment and inter-station spacing of the TA are sufficient for imaging the main features of lithospheric structure in this region. We show that Sp CCP stacks can map variations in crustal thickness, even in areas with thick sedimentary cover, and confirm earlier reports of relatively small velocity jumps across the Moho beneath the Colorado Plateau. Beneath areas that have undergone substantial extension in the Neogene - including the eastern Great Basin, the southern Basin and Range, and the southern Rio Grande Rift - we detect strong Sp conversions across a relatively shallow (60-80 km) seismically-defined LAB. We image similarly thin lithosphere beneath the High Rockies, which implies that the lithosphere did not thicken during the predominantly compressional mode of deformation that uplifted the Rockies, or that it thinned due to melt infiltration accompanying Paleogene and Neogene magmatism. Beneath areas that have remained relatively undeformed - including the Wyoming Craton and the Central U.S. Craton - we detect Sp conversions in the 90-140 km depth range that are substantially weaker and more distributed in depth than those beneath less stable regions. Beneath the Colorado Plateau, Sp CCP stacks show that lithospheric thinning has accompanied magmatic encroachment, so that the lithosphere beneath the margins of the Plateau produces Sp conversions indistinguishable to those from the surrounding extensional provinces. Beneath the central portion of the Plateau, a negative phase interpretable as the LAB reaches depths of ~120 km. The observed variations in lithospheric structure across structural blocks with different magmatic and deformational histories imply that: 1. Seismically observable wholesale lithospheric thinning accompanies wide-mode extension; 2. Magmatism in the Colorado Plateau and the High Rockies is associated with strong and shallow seismic LABs; 3. Mid-lithospheric discontinuities are present beneath tectonic blocks, even when a weak, deep, seismic LAB is also present; 4. Mid-lithospheric discontinuities produce weaker Sp conversions and are more distributed in depth than seismically-observed LABs.

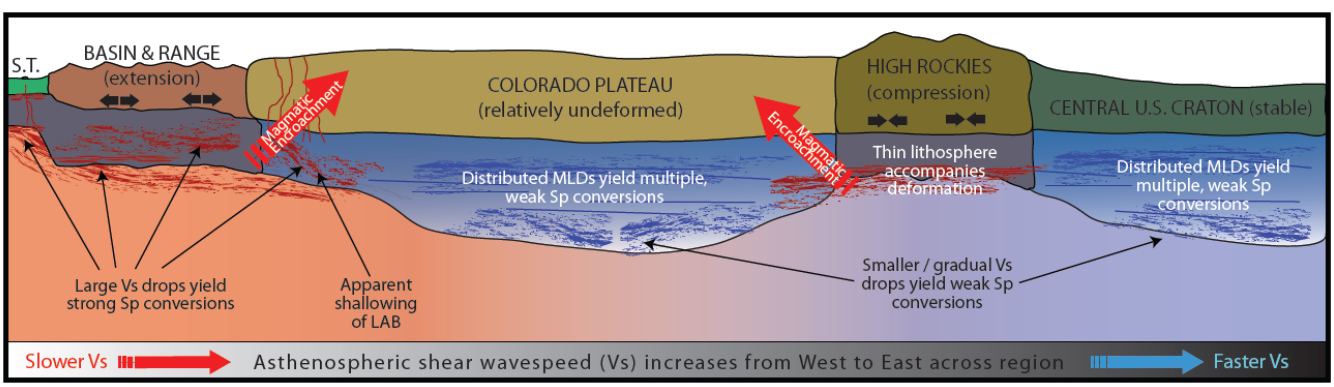

Figure 1 – Schematic representation of variations in lithospheric thickness, the character of the mid-lithopsheric discontinuities (MLDs) and the lithosphere-asthenosphere boundary (LAB) across the western United States.