Geophysical Research Abstracts
Vol. 13, EGU2011-13560, 2011
EGU General Assembly 2011

Lithospheric structure of the Colorado Rockies from CREST and TA seismic data

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The Southern Rocky Mountains reside in west-central Colorado and mark the transition from the tectonically active Western US to the stable North American Craton. Located between the Colorado Plateau and the Great Plains, far from the active plate margin, the Southern Rockies have experienced a protracted history of lithospheric deformation and igneous activity resulting in a topographic high rivaling any other in North America. This region has an average elevation of >2500 m and is coincident with regions of high heat flow (up to >100 mW/m2), negative bouguer gravity (lowest values of <-300 mgals), and low crust and upper-mantle seismic velocity measurements. Some of the current lithospheric architecture was developed during the Laramide Orogeny although epeirogenic surface uplift and magmatism has continued through the Late Cenozoic. The mechanisms controlling post-laramide uplift and topographic support are contested although it appears that mantle processes are an important factor, e.g. mantle thermal/compositional heterogeneity, lithospheric heating, dynamic flow pressures and small scale convection.

In this study we present P and S wave receiver function and surface wave tomography results from seismic data collected by the CREST and Transportable arrays. The tomography dataset consists of dispersion measurements from ambient noise and ballistic surface waves. The velocity model derived from these data shows that the crust beneath the highest topography, e.g. the San Juan Mountains and the Sawatch Range, is low velocity relative to the surrounding regions with a mean crustal Vs of <3.5 km/s. The P wave receiver function dataset includes over 200 teleseismic events and is migrated to depth using the 3D surface wave tomography model via the common conversion point (CCP) stacking methodology. The resulting CCP stack is used to estimate the crustal thickness across the array. A negative correlation is found between elevation and crustal thickness; the high topography is underlain by the thinnest crust (40-43 km) in contrast to the thicker crust (47 to >50 km) of the western Great Plains and eastern Colorado Plateau. These results clearly show that the high topography is not supported via Airy isostasy. Our findings are in general agreement with regional crustal thickness and velocity estimates from Transportable Array data although our results offer higher spatial resolution due to the increased station density. For example, the CCP stack reveals a NE striking lineament of thickened crust in the SE portion of the array near the northern San Luis basin. Cross sections show some evidence of crustal imbrication and we speculate that this structure manifests a Proterozoic aged suture.

To investigate the structure of the upper-mantle, a preliminary S wave receiver function dataset is calculated from 80 teleseismic events and includes direct S and SKS arrivals. The resulting CCP stack finds a complex upper-mantle structure which varies strongly from east to west across the array. Beneath the eastern portion of the array, two negative velocity contrasts are imaged near 75 and 175 km depth. In contrast, beneath the western portion of the array there is a single negative contrast found at 125 km depth. The depths of these shallow arrivals are correlated with a negative velocity gradient found in the surface wave tomography model. This shear wave velocity gradient marks the transition from >4.4 km/s uppermost mantle lid and the underlying 4.2 km/s mantle. Based on these observations we speculate that the S wave receiver function CCP stack is imaging the lithosphere-asthenosphere boundary and that the laterally variable structure is due to the transition from stable North American craton to the active Western US.