Geophysical Research Abstracts
Vol. 16, EGU2014-12941, 2014
EGU General Assembly 2014

Shear-wave structure in the crust and upper mantle beneath the central Tien Shan from surface wave tomography

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The Tien Shan is the world's largest and most active intracontinental orogen with a shortening rate of 20 mm/yr and earthquake magnitude up to 8.0. It is located in central Asia and its tectonic reactivation is usually attributed to the India-Eurasia collision. In order to better understand the formation and evolution of the Tien Shan we constructed a 3-D shear wave velocity model beneath the central Tien Shan using Rayleigh wave data recorded at 41 broadband stations in the study area. Rayleigh wave phase velocities are obtained from two approaches, the two-plane-wave inversion and the ambient noise tomography. Teleseismic data were used in the first method that provided phase velocity maps in a period range from 20 to 133 s. Shorter periods phase velocities from 8 to 30 s were determined from the ambient noise tomography. These Rayleigh wave dispersions were then used to determine 3D shear wave velocity variation beneath the central Tien Shan.

Significant low velocity anomalies in the upper crust (0-10 km) correlate well with sediment rocks in the Tarim basin, Lake Issky Kul, and Naryn basin. The lowest velocity in the lower crust is beneath the high range south to the Issky Kul. A fast velocity anomaly is imaged beneath the northern Tarim block from lower crust to top upper mantle. This anomaly penetrates northward to the western Tien Shan range, indicating the underthrusting of the Tarim basement. The most obvious feature in the mantle is a circular slow anomaly to at least 150 km beneath the Naryn basin in the west of the central Tien Shan. One interpretation for this slow anomaly could be asthenosphere upwelling caused by lithospheric root detachment. However, the crustal thickness beneath the Naryn basin is relatively thin compared to the surrounding ranges, suggesting less deformation in the lithosphere. A favorable mechanism for this slow anomaly is high water or volatile content released by the subducted slab during the accretion process of the Tien Shan mountain. The relatively strong continental basement rock in the crust under the Naryn basin probably helped to keep the volatile and associated partial melt from going through the crust. The overall observations indicate that the Tien Shan was built on a weak and complicated lithosphere.