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Evidence for deeply subducting Asian lithosphere beneath the Pamir-Hindu Kush region from lithospheric imaging

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The Pamir-Hindu Kush region, located north of the western Himalayan syntaxis, remains one of the most puzzling regions in the Indian-Eurasian collision system. In contrast to the Himalaya and Tibet, the Pamir and Hindu Kush feature a narrow, curved zone of intense intermediate depth seismicity, reaching depths greater than 250 km. The Pamir seismicity has been linked to subduction of Eurasian lithosphere. The origin of the material hosting the Hindu Kush earthquakes as well as their relation to the Pamir seismic zone is still a topic of debate. Here we present results from a teleseismic tomography that puts new constraints on the deep structure of this region.
We use teleseismic P-wave travel times of approx. 800 earthquakes recorded by 180 seismic stations of several temporary networks (mainly TIPAGE, FERGHANA, and TIPTIMON) that were deployed between 2008 to 2013 and cover significant parts of the western Tien Shan, Pamir and Hindu Kush. In total about 35.000 P-wave travel time residuals are inverted for P-wave velocity perturbation.

Beneath the Pamir, our velocity model images an arcuate, slab-like high velocity structure, coinciding with the seismogenic plane at the upper level. In the eastern Pamir the high velocity structure does not extend much deeper than the local seismicity but in the south-western Pamir, the structure can be traced to the bottom of the transition zone at about 600 km, indicating the presence of dense, cold Eurasian lithosphere at much greater depths than the depth extent of the seismicity would suggest. The stress regime derived from source mechanisms of intermediate depth earthquakes suggests that the current driving force, pulling the Pamir slab down seems to be this seismically fast body deep in the mantle.
In contrast to the Pamir, the Hindu Kush seismicity does not occur clearly connected to a high velocity structure, but to near average or even low velocities. However a fast anomaly is imaged just below the deepest Hindu Kush earthquakes. The down-dip extensional stress regime governing these earthquakes indicates that the deep, high velocity body is probably not completely detached so that it can still pull on the shallower structure where the earthquakes are occurring.

The Hindu Kush fast anomaly merges at depth with the deepest part of the Pamir slab but both structures are clearly separated at shallower levels. This configuration as well as the common stress regime that drives the Pamir and Hindu Kush earthquakes cannot be easily reconciled with a purely (Greater)India origin of the Hindu Kush earthquakes and mantle anomaly. Nevertheless, it would allow two possible scenarios regarding the tectonic history of the region: either the Pamir and Hindu Kush form two separated down-going structures which only converge at depth or that both anomalies have been connected in the past also at shallower levels but later were torn apart e.g. by a salient in the advancing Indian indenter.