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Imaging continental collision and subduction in the Pamir mountain range, Central Asia, by seismic attenuation tomography

Bernd Schurr (1), Christian Haberland (1), Christian Sippl (2), Xiaohui Yuan (1), James Mechie (1), Felix Schneider (1), and Tipage Team ()

(1) GFZ – German Research Centre for Geosciences, 14473 Potsdam, Germany , (2) Research School of Earth Sciences, Australian National University, Canberra, Australia

Subduction of continental crust is the mode of shortening in continental collision that is the least well understood. It is known to occur, as testified e.g., by now exhumed ultra-high-pressure rocks, despite the fact that continental crust is generally too buoyant to submerge into the mantle. Continental crust may, however, subduct in tow of a leading dense oceanic plate at the last stage of the plate tectonic Wilson cycle. Alternatively, if upper and lower crust detach, the latter, together with the underlying cold mantle lithosphere, may become negatively buoyant, enabling their descent. The Pamir mountains in Central Asia have been one of the few places on Earth, where on-going continental subduction has been postulated based on an active Wadati-Benioff zone. The Pamir is situated on an orographic node northwest of Tibet, between the Tarim and Tajik basins, where the Hindu Kush, Karakorum, western Kunlun Shan and Tien Shan ranges coalesce. It formed in the late Paleogene to Neogene, i.e. approximately during the second half of the India-Asia collision, north of the Western Himalayan Syntaxis, on the Asian (retro)continent.

We use tomography of seismic attenuation to image the lithospheric-scale structure of the Pamir orogen. Attenuation tomography has been shown to be a powerful tool to study deep process-related structures particularly in oceanic subduction zones. Attenuation at this scale may be seen as a proxy for rheology and hence is very sensitive to e.g., homologous temperature and deformation. We use data from a two-year seismic deployment of the Tien Shan-Pamir Geodynamic Program (TIPAGE). The whole path attenuation parameter t* is determined by inversion of P-wave velocity spectra from 1790 earthquakes and then inverted for a 3D attenuation model (Qp) employing a recently published 3D velocity model. We find a prominent continuous crescent-shaped high-attenuation anomaly (HAA) that penetrates from upper crustal levels to depths of more than 100 km. At mantle depths the HAA follows the seismicity and coincides with low seismic velocities and most probably represents subducted crustal rocks. The HAA appears to be sandwiched between regions of low attenuation. To the north and west this probably represents cold Asian lithospheric mantle. To the south the low attenuation may be an indication of the (Indian?) indenter. The structures we image here are distinctively different from oceanic subduction zones, where HAAs usually occur in the mantle wedge above low attenuation oceanic slabs.