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Analysis of local seismicity in the Pamir-Tien Shan-Hindu Kush region, central Asia

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Seismic activity in the region of central Asia outlined by the three orogens Pamir, Hindu Kush and Tien Shan is very high, featuring broadly distributed shallow seismicity as well as frequently occurring mantle earthquakes in the Hindu Kush and Pamir. The latter mark a feature of central Asian tectonics that, although first observed more than 40 years ago, has remained enigmatic to the present day. Earthquake locations from global seismological catalogues show a WSW-ENE striking structure resembling a Benioff zone, which changes its dip direction along strike from steeply northward in the Hindu Kush to southward in the Eastern Pamir. Although the whole region is situated in an intracontinental setting and despite the fact that plate reconstructions show no available oceanic lithosphere of fitting age that could be subducted there, these have been interpreted as evidence for active subduction processes. Several scenarios have been proposed, including one-sided subduction of Indian lithosphere followed by a subsequent overturning of the slab, two-sided subduction of Indian and Asian continental lithosphere next to each other, and drop-like delamination of continental lithosphere in the Hindu Kush. Shallow seismicity in this region of central Asia exhibited a number of the biggest historic intraplate earthquakes. The distribution of shallow activity clearly follows the Pamir's orogenic curvature.

As part of the TIPAGE (TIen Shan PAmir GEodynamic Programme) project, a total number of 40 seismic stations were installed in eastern Tajikistan and south-western Kyrgyzstan for a total duration of two years (2008-2010), with a change in network geometry after one year. These data are complemented in the north by the one-year FERGHANA deployment of 21 broadband stations around the Ferghana Valley in south-western Kyrgyzstan in 2009/10. Additional data were obtained from permanent stations in western Tajikistan, northern and eastern Kyrgyzstan and the Chinese province Xingjiang. In summary, this constitutes a unique dataset covering a region that has not yet been investigated with modern seismological means.

More than 20,000 earthquakes of local magnitude above 2 were identified in our dataset and located using an automatic procedure based on a trigger and event association algorithm and a repicking software. With this strategy, a complete catalogue of events in the study area was obtained. Earthquake locations are currently based solely on P arrival times, automatic determination of S onsets will be implemeted in the near future, which should yield more reliable hypocentral depths. A subset of about 580 events was picked manually in order to assess the accuracy of the automatic scheme. Shallow seismicity is concentrated along the Main Pamir Thrust (MPT), the Pamir's northern margin. According to recent GPS studies, up to 15 mm/yr of convergence are accommodated here, which is nearly half of the rate for the whole India-Eurasia convergence at this longitude. Further shallow seismicity is observed along the suture zones crossing the Pamir in east-west direction (Vanj, Bartang valleys) and in a roughly north-south trending structure from Lake Kara Kul in the north to west of Lake Zorkul in the south. Frequent intermediate-depth earthquakes occur in a relatively narrow band from the Afghan Hindu Kush in the southwest to the Eastern Pamir (Murghab region) in the northeast. Whereas the hypocenters beneath the Hindu Kush form a continuous, near-vertical structure that reaches nearly 300km depth, deep seismic activity in the eastern Pamir is confined to a narrow, southward-dipping region extending from about 90 to 180 km in depth, which appears to be disconnected from shallow seismic activity at the MPT. The transition from a northward to a southward dip seems to progress rather continuously along strike.