Geophysical Research Abstracts
Vol. 14, EGU2012-8645, 2012
EGU General Assembly 2012

Remarkable recurrence of M∼7- intermediate-depth earthquakes beneath the Hindu Kush

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Recurrent activity of intermediate-depth earthquakes (h60-300km) is remarkable beneath the Hindu Kush, the western vicinity of the Himalayas where the Indian plate is colliding against the Eurasian plate. Utsu (1994) pointed out that beneath the Hindu Kush (around 36.4 degrees north, 70.8 degrees east, h220km) M7-class earthquakes had recurred five times about every nine years; 1956 (mb6.5), 1965 (mb7.5), 1974 (mb7.1), 1983 (Mw7.4), and 1993 (Mw7.0). Moreover, a Mw7.3 earthquake occurred at the same place in 2002.
In order to examine whether these are characteristic earthquakes or not and to discuss the mechanism of their occurrence, we first relocated the 1956 main shock and the earthquakes beneath the Hindu Kush during the period from 1964 through 2007 by the Hurukawa's (1995) Modified Joint Hypocenter Determination method. The main shocks and aftershocks of later five large events are included in these events. Out of 4,103 earthquakes with depth range of 100-300km, 3,372 hypocenters were well relocated.
The results show (1) a southward steeply dipping hypocenter distribution around the depth of 190 to 220 km, while the overall intermediate-depth seismicity shows almost vertical shape with slight northward-dipping. (2) The 1956, 1965, 1974, and 1983 main shocks occurred at almost the same place. The 1993 main shock took place about 15 km southeast of the formers. The 2002 main shock took place about 30 km northwest of the earlier four events. (3) These five hypocenters are within about 35 km alignment striking in the ESE-WNW direction. Focal mechanisms of all the five large earthquakes are very similar, showing ESE-WNW running and southward-dipping high-angle reverse faulting with a down-dip tension.
We investigated their rupture processes by inversion analyses of teleseismic body-waves (Kikuchi and Kanamori, 2003) and obtained the following results: (1) Main slips of the 1965, 1974, and 1983 events existed almost at the same place. (2) The 1993 rupture propagated toward northwest and deep direction. The largest slip took place on the northeastern deep area near the initial rupture point. (3) The 2002 largest slip took place about 40 km southeast from the initial rupture point. (4) Concerning Mw and slip amounts, the 1965 (Mw 7.6/4.9m) event was the largest, the 1983 (7.4/2.7m) and 2002 (7.3/1.4m) ones were also large, but the 1974 (7.1/0.8m) and 1993 (7.1/0.8m) events were relatively small.
Thus, these five large earthquakes are not considered to be exactly characteristic earthquakes, although their asperities were overlapping considerably. However, their rupture zones concentrated within a very narrow area, and if we take errors of hypocenter location and waveform analyses into account, it may be possible that they were repeating ruptures of an identical fault plane. Beneath the Hindu Kush, nearly vertical slab is inferred to exist down to 300 km or so, by seismic tomography. Probably there exists a certain mechanism of concentration of slab-pull tensional force to a narrow zone (h200-220km), which controls a surprisingly regular recurrence of M7-class earthquakes with a remarkably short repeat time. The next event may be imminent in this region.