

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

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Remarkable activity of intermediate-depth earthquakes (h 60 to 300 km) exists 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, h 220 km) M 7-class earthquakes had recurred five times every about nine years; April 6, 1956 (h 224 km, mb 6.5), March 14, 1965 (h 219 km, mb 7.5), July 30, 1974 (h 211 km, mb 7.1), December 30, 1983 (h 215 km, Mw 7.4), and August 9, 1993 (h 230 km, Mw 7.0). The successive time intervals are 8.9, 9.4, 9.4, and 9.6 years. Moreover, on March 3, 2002, 8.6 years after the last event, a Mw 7.3 earthquake took place in the same place at a depth of 220 km.

In order to examine whether these earthquakes are characteristic earthquakes or not and to discuss the mechanism of their occurrence, we first carried out a simultaneous relocation of all earthquakes beneath the Hindu Kush (depth 0 to 300 km, mb not smaller than 4, total number 1950) during the period from 1964 through 2003, including the 1965, 1974, 1983, 1993, and 2002 large events, using ISC data and Hurukawa's (1995) Modified Joint Hypocenter Determination (MJHD) method. Among 1650 earthquakes which fit the calculation condition, 1620 were well relocated. The results are: (1) We can see a southward steeply-dipping hypocenter distribution around the depth of 200 to 220 km, while the overall intermediate-depth seismicity shows almost vertical shape with slight northward-dipping. (2) The 1965, 1974, and 1983 earthquakes occurred almost in the same place at a depth of 208 to 209 km. (3) The 1993 event took place about 15 km east of the formers at a depth of 207 km. (4) The 2002 earthquake took place about 18 km west-northwest of the earlier three events at a depth of 220 km. (5) These five hypocenters are within about 35 km alignment striking in the ESE-WNW direction.

Focal mechanisms of all 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 and obtained the following results: (1) The asperities of the 1965, 1974, and 1983 events existed almost in the same place, near the hypocenters. (2) The rupture of the eastern 1993 earthquake propagated toward the west and its asperity was 10 to 20 km west of the rupture starting point. (3) The rupture of the westernmost 2002 event propagated toward the east and its asperities were 20 to 30 km east of the rupture starting point and in a 20 to 30 km deeper part. (4) Concerning Mw and slip amounts, the 1965 event was the largest (7.6/5.7m), the 1983 and 2002 ones were also large (7.4/2.2 to 2.8m), and the 1974 and 1993 events were relatively small (7.0 to 7.1/0.5 to 0.6m).

Thus, these five large earthquakes are considered not to be complete 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 at a depth of 200 to 220 km, which controls a surprisingly regular recurrence of M 7-class earthquakes with a remarkably short repeat time. The next event may occur in 2010 to 2011.

We used the MJHD program written by N. Hurukawa and the teleseismic body-wave inversion program written by M. Kikuchi and H. Kanamori (<http://www.eri.u-tokyo.ac.jp/ETAL/KIKUCHI/>), and we had kind help of S. Yoshida and O. Murakami. We thank all these people.