Episodic deep low-frequency tremor and slow slip in Southwest Japan

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Recently, new geophysical phenomena have been discovered according to the development of dense seismic networks in Japan. One of the new observational facts is the deep low-frequency tremor in the southwest Japan detected by the NIED Hi-net (Obara, 2002). Moreover, slow slip events have been detected at the same time periods associated with the active tremor using by tiltmeters, that is horizontal components of high-sensitivity accelerometer installed in the Hi-net observatories (Obara and Hirose, 2003). In this paper, characteristics of the tremor and the slow slip, their relationship and regional differences are focused.

Tremors are distributed along the strike of the subducting Philippine Sea plate from southern Nagano to the Bungo Channel. However, the distribution is not homogeneous in the narrow belt but spatially clustered. In the western part of Shikoku, where is the most active area of the tremors, many small activities are detected frequently, however the major tremor activity with the duration longer than a few days repeats with a period of about 6 months. At stations near the tremor area, step-like tilt changes have been detected a several times associated with the periodic major tremor activities. The tilt change is due to the slow slip at near the subducting plate boundary. The tilt steps are not instantaneous but gradually changed for several days. Therefore, it is quite different from the slow slip detected in Tokai area. There were four major tremor active stages in the western Shikoku in the years of 2001 and 2002. In each active stage, the tremor migrated to opposite directions; from northeast to southwest in January 2001 and February 2002, and from southwest to northeast in Augusts 2001 and 2002. The direction of the tilt vector changes according to the migrating tremor. This means that the source of the slow slip migrates with tremor. In February 2003, the tremor occurred at the northeast part with very small tilt change and without migration. At the end of August 2003, the tremor started in the Bungo Channel and migrated to the northeast direction with a velocity of about 10km/day as a typical pattern of the summer type. The short-term slow slip event with time period of 1 week occurred associated with the migrating tremor activity. After the sequence of the migration, the tremor activity continued intermittently for three months in this region and the long-term slow slip event with duration of 3 months were detected by GPS and tiltmeter. Such a long-term slow slip occurred at the same place 6 years ago (Hirose, et al., 1999). As mentioned above, in the western Shikoku area, short-term and long-term slow slip events repeatedly occur with the strong correlation to the occurrence of tremor.

The coupled phenomenon of the tremor and the slow slip is also observed in Cascadia subduction zone, where the young Juan de Fuca plate subducts beneath the North American plate. In this area, the episodic tremor and the slow slip occur with a time interval of 13-16 months and each active stage continues for about two weeks with migrating.

Along the tremor belt zone in Southwest Japan, there are some places where the slow slip is detected associated with the active tremor. In the east of Shikoku, the major tremor activity repeats with a time period of 2 or 3 months has also observed corresponding to tilt changes detected at a nearby station from the tremor source area. In the middle part of Mie in the Kii Peninsula, step-like tilt changes are recognized associated with the active tremor stage with a period of about 6 months. On the other hand, in Tokai area the slow slip continues for a few years from middle of 2000 (Ozawa, et al., 2002). The tremor area is located nearby the slow slip area and we expect an interaction between the tremor and long-term slow slip; however, there is no clear relationship like as the simultaneous occurrence of the active tremor and the short-term slow slip.