A possible slow slip event beneath the Kii Peninsula inferred from historical tilt records in 1970’s

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Slow slip events (SSEs) have been often observed prior to large earthquakes such as the 2011 Tohoku-oki earthquake and the 2014 Iquique earthquake (e.g., Kato et al., 2012; Mavrommatis et al., 2014; Ruiz et al., 2014). In addition, numerical studies demonstrated that intervals of SSEs became shorter in the latter half of the interseismic period (e.g., Matsuzawa et al., 2010). Therefore, activities and variations of SSEs in time and space provide important clues to anticipated large earthquakes.

Many studies have investigated activities of SSEs based on dense geodetic observation networks established in the early 2000’s (e.g., Sekine et al. 2010; Nishimura et al. 2013). On the other hand, there are few reports before the establishment of such dense networks (Kimata et al., 2001; Kobayashi and Yamamoto, 2011). Here, we report a possible SSE beneath the Kii Peninsula based on historical tilt records in 1970’s.

We used tilt data recorded in Kishu observatory in the Mie Prefecture operated by Kyoto University. Horizontal-pendulum tiltmeters were installed in directions of N57W and N33E. The original tilt data was drawn on bromide (light-sensitive) papers, each of which consists of tilt records for about one week. We have digitized bromide records in 1970’s and connected to a single continuous record.

In the late November in 1973, there was a slow tilt change of >0.5 μrad down to the northeast that lasted for a few days. Assuming that this crustal deformation was due to an SSE along the plate boundary, we have constructed a possible model of SSE. Because it is difficult to constrain fault parameters from a single station record, we conducted a forward modeling assuming already known SSE models beneath the Kii Peninsula obtained by Nishimura et al. (2013). Among 42 template fault models from 1996 to 2012, 3 models were able to qualitatively explain the direction of tilt changes. The centroids of these fault models locate ~30-50 km western side of the observatory. However, the calculated tilt change was about one order smaller than the observed one. Therefore, it is possible that the amount of slip was greater than the template models or the location of SSE was closer to the observatory.

Around the source area, relatively large (magnitude 5.9) earthquake and the following magnitude 5.4 earthquake occurred near the plate boundary on November 25, just before the initiation of the tilt change. The seismicity in this area was usually low, and thus these earthquakes may relate to a possible SSE.

The Kishu observatory have recorded tilt changes since 1947, soon after the 1946 Nankai earthquake. Therefore, further detection of possible SSEs in the latter half of the 20th century will reveal how SSEs behave after large earthquakes.

Acknowledgments:

We used tilt records at Kishu observatory operated and preserved by Disaster Prevention Research Institute, Kyoto University.

Keywords: Slow slip events, Tiltmeters, Kii Peninsula

