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Modeling of GPS-based crustal movement around the Atotsugawa fault system

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We have been conducting continuous GPS observation around the Atotsugawa fault system in the Niigata-Kobe Tectonic Line (NKTZ). From these results, we construct kinematic models based on the observed GPS velocity field. The Atotsugawa Fault has some special features such as the remarkable along-strike micro-seismicity (Ito et al., 1997) and the surface creep of 1.5mm/yr at its eastern section (GSI, 2002). These observations indicate laterally heterogeneous nature of the fault. Taking such heterogeneity into account, we try to model the tectonic loading process of the Atotsugawa fault system.

We analyzed continuous GPS data of 15 sites by Nagoya University and Kyoto University, 6 sites by GSI (GEONET), and 5 International GNSS Service (IGS) sites with the Bernese GPS Software version 4.2 (Hugentobler et al., 2001). We analyzed data from IGS, GEONET, and the eastern profile crossing the creeping region of the Atotsugawa fault, from 1998. On the other hand, GPS sites along the western profile crossing the no-creeping section started at the end of 2002. We analyzed the GPS data until March 2005, and estimated velocities at each site from daily coordinate time series.

The obtained GPS velocity field exhibits E-W shortening of about 10 mm/yr across the Atotsugawa fault. Along the eastern profile, velocities gradually change according to the distance from the fault trace. On the other hand, the western profile results show discontinuities at both the Atotsugawa and the Ushikubi fault. GPS sites south of the Atotsugawa fault have similar velocities, implying a rigid block motion. The velocity of southernmost site (0058) is significantly different from other sites, indicating some deformation along the Takayama fault zone.

We constructed two types of kinetic model.

1) First, we analyzed the two profiles crossing the fault separately and estimated the relative block motion and the effect of fault locking following Hirahara et al. (2003). The eastern profile velocity pattern by assuming a full-locking of the Atotsugawa Fault. Meanwhile, we incorporate 0.8 mm/yr creeping of the Atotsugawa fault and locking effect of Ushikubi fault to explain the western profile data. These models explain the observation well. The model contradicts with previous models about the creeping portion of the Atotsugawa Fault, but is consistent with micro-seismicity data.

2) We applied the block-fault model (Matsu'ura et al., 1986) to our GPS data in order to discuss crustal deformation of a wider area in NKTZ. A rectangular area around the Atotsugawa fault system was divided into 6 blocks and 11 faults are incorporated as block boundaries. The result demonstrates that the 50km-wide zone between the Ushikubi fault and the Takayama fault corresponds to NKTZ, and motion of the outer regions are well described by an 10mm/yr E-W shortening of rigid blocks.

We described crustal movement around the Atotsugawa fault system with kinetic models based on GPS observations. Deformation of the Atotsugawa fault system has lateral heterogeneity corresponding to the micro-seismicity. The Takayama fault zone may have active deformation, which we need to investigate more by establishing additional GPS sites.