Geodetic data inversion for the 1923 Kanto, Japan, earthquake incorporating the West-Sagami-Bay Fracture

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The 1923 Kanto, Japan, earthquake (Mjma 7.9) took place on the plate interface along the northwesternmost part of the Sagami trough in Sagami Bay, where the Philippine Sea plate (PHS) is being subducted beneath Honshu Island. Its source region is located just on the east of the Izu Peninsula, which is the northern tip of the PHS and colliding against Honshu. Ishibashi (1988, 2004) hypothesized a West-Sagami-Bay Fracture (WSBF), a north-south striking tear fault (westward-steeply dipping left-lateral reverse fault) within the PHS, beneath the northwestern part of Sagami Bay, just east-off the Izu Peninsula, and further north beneath the land area. He considered that the WSBF had been separating the subducting part of the PHS on its eastern side from the colliding part of the PHS (the Izu block) on its western side. The WSBF, however, has not yet been directly detected by seismic survey.

During the 1923 Kanto earthquake remarkable crustal uplift as high as around 2 meters took place at Hatsu-shima Island (HI) and Manazuru Cape (MC) in the northwestern part of Sagami Bay. This coseismic uplift cannot be explained by fault models of the Kanto earthquake so far proposed by means of geodetic data inversion (e.g., Matsu'ura et al., 1980; Wald and Somerville, 1995; Kobayashi and Koketsu, 2005; Pollitz et al., 2005) because this uplift was not taken into account due to lack of geodetic data. On the other hand, Ishibashi (1988, 2004) inferred that the 1923 coseismic uplift at HI and MC had been brought about by sub-faulting on the WSBF, which he presumed had occurred simultaneously with interplate main faulting along the Sagami trough. HI and MC are located on the hanging-wall side of the WSBF. Ishibashi (2004) showed a static fault model of the 1923 Kanto earthquake incorporating the WSBF by forward modeling.

In the present study, in order to examine the WSBF hypothesis and to obtain a better static fault model of the 1923 Kanto earthquake, we carried out inversion of coseismic crustal deformation data of this earthquake. We used a computer program developed by Yabuki and Matsu'ura (1992) and modified by Yoshioka.

We assumed two fault planes; an interplate main fault along the Sagami trough following previous studies and a fault corresponding to the WSBF. We used 198 precise leveling data, which were the same as previous studies, and 171 horizontal displacement vectors obtained by Fujii and Nakane (1982) through net adjustment employing not only the first-order triangulation data but also second-order ones, which were much more than vectors used in previous studies. In addition, we used vertical displacement data of 1.8 meter at HI and 2 meter at MC, which were estimated from reports on immediate post-seismic field investigations.

As a result of inversion, we obtained coseismic slip distribution similar to that of Wald and Somerville (1995) on the main fault. As for the fault corresponding to the WSBF we obtained slip distribution showing left-lateral reverse faulting. While residuals of vertical displacements at HI and MZ and horizontal displacement at HI were very large for previous fault models, those of vertical and horizontal displacements at HI have been improved remarkably, though that of vertical displacement at MC remained large.

In conclusion, it has been shown objectively that the crustal deformation at HI and MC associated with the 1923 Kanto earthquake could be explained well by taking faulting of the WSBF into account. However, it is a matter of further study to model the geometry of the WSBF, which is considered a high-angle fault meeting with the interplate main fault with an acute angle, more realistically. We should also examine carefully local effects on the crustal deformation at MC.

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