Physical Interpretation of Long-term Crustal Movements in Kanto District Based on a 3-D Plate Subduction Model in and around Japan

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The Kanto district is one of the most interesting regions from a tectonic point of view. In the south of this region, there exists a triple junction, and in the west, the Izu-Mariana arc is colliding with the Honshu arc at the base of the Izu peninsula. Furthermore, in this region the Philippine Sea plate is descending beneath the North American plate to the northwest along the Sagami trough, and the Pacific plate is descending beneath both the North American and the Philippine Sea plates to the west along the Japan trench and the Izu-Mariana trench, respectively. The 3-D configuration of the plate interfaces is very complex in the Kanto district. The long-term crustal movements in the Kanto district are very complex, reflecting the complex tectonic setting.

We developed a kinematic model of steady plate subduction with the 3-D standard plate interface model, and computed the long-term crustal movements in the Kanto district. The crust and mantle structure used in the computation is an elastic surface layer overlying a Maxwell-type viscoelastic half-space. The interaction between oceanic and continental plates is rationally represented by the increase of relative displacement (fault slip) along the plate interface. The fault slip rate at each point on the plate interfaces is calculated from NUVEL-1A. We obtained the whole image of the long-term crustal movements in the Kanto district by combining various observations with different time-scales, such as the heights of the Holocene highest marine terraces (6,000 yr), the heights of the Shimosueyoshi surface (125,000 yr), and the free-air gravity anomalies (1000,000 yr). The remarkable features of the long-term crustal movements are the rapid uplift in the southern part of Boso peninsula and the existence of the nearly stable (relatively subsidence) central area surrounded by uplift regions. These features of the observed crustal movements are well explained by the kinematic plate subduction model with the realistic 3-D geometry of the plate interfaces. Therefore, we may conclude that the essential cause of the long-term cructal movements in the Kanto district is in the steady subduction of the Philippine Sea plate and the Pacific plate there.

To make clear the mechanism of the long-term crustal movements, we examined the contributions of the Pacific plate subduction and the Philippine Sea plate subduction separately. In addition to the common features of the island-arc uplift and the ocean-trench subsidence, the large-scale horizontal bend of the Pacific plate at Cyoshi-oki brings about subsidence in broad regions around there. The cause of such broad subsidence is in the horizontal extension of the overlying plates due to steady slip motion along the curved plate interface. The pattern of crustal movements due to the Philippine Sea plate subduction is very complicated. The pattern is characterized by the rapid uplift around the southern part of the Boso peninsula and weak subsidence in the central part of the Kanto district. The cause of such crustal movements is in the complex geometry of the Philippine Sea-North American plate interface. The most essential point is that the Philippine Sea plate is bending downward beneath the Boso peninsula because of its running on the Pacific plate at its eastern rim. On the basis of these considerations, we may conclude that the Tokyo Bay and Koga forming-basin movements are caused by the superposition of two different types of plate-to-plate interactions; the interactions at the Philippine Sea-Pacific plate interface and the Philippine Sea-North American plate interface.