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The effect of the collision of the Izu-Bonin arc on long-term deformation in the Kanto region, Japan

Akinori Hashima[1]; Toshinori Sato[2]; Tanio Ito[3]

[1] Earth Sci, Chiba Univ; [2] Chiba Univ.; [3] Dept. Earth Sciences, Fac. Sci., Chiba Univ.

The Kanto region of Japan is in a highly complex tectonic setting with four plates interacting with each other: the Philippine sea plate descends beneath the Eurasian and North American plates and furthermore the Pacific plate descends beneath the North American and Philippine sea plates. In addition, the Izu-Bonin (Ogasawara) Arc on the Philippine sea plate is colliding with the Japan islands. In such an environment, rapid uplifts are observed in the southern part of the Boso peninsula, while subsidence is observed around the Tokyo Bay. Such a basic deformation pattern in the Kanto region is explained by Fukui et al. (2003) with a simple plate subduction model which ignores the effect of the collision of Izu-Bonin arc. However, large landward indentation of the plate boundary from the Sagami trough to the Suruga trough implies that the collision of the Izu-Bonin arc also contributes significantly to the deformation of the Kanto region. In this study, we estimate the effect of the collision of Izu-Bonin arc on the tectonics of the Kanto region by using a kinematic plate subductioin model based on the elastic dislocation theory.

Mechanical interaction between plates can be represented by the increase of the displacement discontinuity (dislocation) across plate interfaces. Sources of internal deformation are theoretically spatial variation of dislocation vectors both in their magnitude and direction. Based on the above idea, we can construct deformation model due to plate subduction. In the actual computation, we require geometry of plate boundaries, distribution of slip rate vectors on the plate boundaries, and the expressions of deformation fields due to a dislocation. In this study, we use the CAMP standard model (the 3-D plate boundary model in and around Japan) as the geometry of plate boundaries. The distribution slip rate vectors on the plate boundaries is calculated from NUVEL-1A plate motion model for simple plate subduction. On the other hand, in the collision area, the plate with arc crust cannot easily descend because of its buoyancy. This can be represented by giving slip deficit. Then, we computed long-term deformation fields due to plate subduction expressed as above by using the expressions for internal deformation due to dislocation in an elastic-viscoelastic layered half-space (Hashima et al., 2008).

To examine the effect of collision, we computed several deformation patterns for different width of collision areas. First, as shown by Fukui et al. (2003), simple plate subduction produces basic deformation pattern with uplifts in the southern part of the Boso peninsula and subsidence around the Tokyo Bay. Then, we added effect of the collision of the Izu-Bonin arc. Remarkable subsidence occurs from the Izu-Oshima to the colliding Izu peninsula and moderate uplifts occur in the surrounding area of the collision area, particularly the frontal area of the Izu peninsula. The basic pattern of subsidence in the Tokyo Bay area and uplifts in the southern part of the Boso peninsula appears to shift in the east-west direction depending on the dimension of the collision area.