Rapid uplift in SW Taiwan caused by fold growth

*Yoshiki Takei[1], Youichiro Takada[2]

1. Department of Natural History Sciences, Graduate School of Science, Hokkaido University, 2. Hokkaido University

The Taiwan orogeny is result of the continental collision between the Luzon arc on the Philippine Sea plate and the Eurasian continental margin. GNSS velocity field indicates rapid and on-going east-west compression (e.g., Yu et al., 1997; Tsai et al., 2015). Due to such background compression, very rapid uplift up to 37 mm/yr has been aseismically proceeding in the southwestern part of Taiwan, which is detected by levelling and InSAR measurements (Ching et al., 2016; Tsukahara and Takada, 2018). Tsukahara and Takada (2018) showed that such rapid uplift cannot be explained solely by fault motion, and they concluded that a fold growth would contribute to the uplift motion as suggested by Ching et al. (2016). Actually, mud diapirs are widely distributed from South China Sea to the coastal area of Southwest Taiwan, and some of those are observed as mud volcanoes on land (e.g., Lin et al., 2009; Hsu et al., 2013; Doo et al., 2015). From physical point of view, mud diapirism can be regarded as a fold growth with buoyancy under strong horizontal compression. There is no previous study, however, that quantitatively estimates the possibility of fold growth in SW Taiwan. In this study, we quantitatively examined the fold growth rate in SW Taiwan on the basis of continuum mechanics. First, we modeled the earth’s crust as non-linear viscous fluid following power-law creep. Next, considering that the background stress is much larger than the stress perturbation caused by the fold growth, we linearized the governing equations and analytically calculated the fold growth rate following the conventional method (Smith, 1977; Fletcher and Hallett, 1983). So far, this approach has been applied to foldings periodic in space, while the folds in SW Taiwan (on land) are not periodic but rather isolated. Following Bassi and Bonnin (1988) formulation, therefore, we assumed a Gaussian shaped fold at initial stage, and calculated its growth rate under various conditions. The medium consists of a substratum (mud) and a brittle surface layer. The power exponent is set as one for the substratum (Newtonian) and a thousand for the surface layer. In addition, we considered surface erosion and sedimentation that modify the effect of gravity as pointed out by Martinod and Molnar (1995).

The result of calculation shows that the Gaussian shaped perturbation can grow up for a certain combination of model parameters consistent with observations. Also, we found that surface erosion and sedimentation prompt the fold growth. The surface uplift and subsidence rates associated with the Gaussian shaped fold growth are roughly consistent with levelling and InSAR measurements. Among all, the subsidence pattern is well explained by the folding, which could not be explained by the elastic dislocation model (Okada, 1992). On the other hand, the largest uplift rate in the numerical simulation is about 10 mm/yr smaller than the ones given by InSAR and levelling surveys, which indicates that large displacement gradient in the observed result was not well reproduced by the simulation. The actual folding in SW Taiwan might associate brittle failures as well as viscous deformation. We will combine both fault motion and fold growth to explain the mechanisms of rapid aseismic deformation in SW Taiwan in the future.

Keywords: Aseismic crustal deformation, Fold growth, Taiwan

