Modeling strain concentration zones in Kyushu Island considering heterogeneous rheological structure

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Recent large intra-plate earthquakes in Japan have occurred in strain concentration zones which have been revealed by the analysis of dense GNSS data. For example, the 2016 Kumamoto earthquake occurred in a strain concentration zone in Kyushu Island (Nishimura et al., 2016) and the 2016 Central Tottori earthquake occurred in the Sanin strain concentration zone (Nishimura and Takada, 2017). It is thought that strain concentration zones are caused by heterogeneous rheological structures that are the result of heterogeneous thermal structures and distributions of water content and preexisting geological structures. This study models the Kyushu strain concentration zones to understand the generation processes of large intraplate earthquakes by considering the heterogeneous rheological structure.

Geothermal gradients according to data obtained from Hi-net (Matsumoto et al. 2007) and from the Geological Survey of Japan (Tanaka et al. 2004) indicate high geothermal anomalies in the Beppu–Shimabara graben zone, in particular, regions that include the Kujyu and Aso volcanoes and the Beppu region. Geothermal gradients are also high in the regions of the Kirishima and Sakurajima volcanoes. The distribution of the geothermal gradient is similar to that of the cut-off depth of the seismicity obtained by Matsumoto et al. (2016).

This study models strain concentration zones by considering the heterogeneous rheological structure using the finite element method (Shibazaki et al., 2007), with nonlinear viscoelasticity and Mohr–Coulomb plasticity. From the observed geothermal gradient distribution, we assume that temperature increases with depth. We set the boundary conditions as extensional in the N–S direction and compressional in the E–W direction. We reproduce the strain concentration zone along the Futagawa fault, where the 2016 Kumamoto earthquake occurred. However, we cannot reproduce the strain concentration zone along the Hinagu fault. Therefore, we include the low-strength region around the Hinagu fault zone considering the existence of an ancient accretional complex, and the low-strength region in the northern part of the Okinawa Trough. By considering these low-strength regions, we can reproduce the strain concentration zones along the Futagawa and Hinagu fault zones, the pattern of which is similar to the observed one.

Keywords: strain concentration zone, Kyushu, finite element method, thermal structure, Okinawa Trough

