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# Faulting processes controlled by nonlinear flow in the lower crust in the northeastern Japanese island arc

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The Japanese island arc is a typical island arc that has various tectonic activities, including volcanism and the occurrence of large inland earthquakes. In the rheological model of the northeastern Japanese island arc proposed by Shimamoto (1990), the lithosphere is very thin (20 km) and undergoes a large deformation because of hot geotherms. To construct a model of the slip and deformation processes in the deeper parts of the seismogenic zones beneath northeastern Japan, we performed a finite element analysis considering nonlinear viscoelasticity and plasticity. Our finite element code was developed based on the GeoFEM parallel finite element code by using plugins to adopt several nonlinear functions.

Seismological and geothermal observations indicate that hot regions exist beneath the Backbone Range in northeastern Japan. We examined the effects of these hot regions in the crust in a compressional tectonic setting to model the deformation and faulting beneath the Backbone Range. The crust comprises two layers: the upper crust (quartz diorite) and the lower crust (wet diabase). The numerical results showed that contraction due to nonlinear viscous flow occurs in the hot region in the lower part of the crust; this results in shear faulting in the upper part of the crust. A weak viscous zone appears in the lower part of the upper crust and a strong viscous or plastic zone appears in the upper part of the lower crust. Above these strong viscous or plastic zones, stress concentrates and shear zones develop. In some areas, two parallel hot regions exist along the northeastern Japanese island arc. Considering these hot regions, we can reproduce two couples of oblique fault zones that are consistent with observations. We also examined how the existing listric fault zones are activated. If the fault zone exists in the same region where stress concentrates due to nonlinear flow in the lower crust, it is activated. The progress of faulting also induces strong localized shear deforma-

tion in the lower crust. Numerical results show that the generation processes of large inland earthquakes in northeastern Japan are determined by nonlinear flow processes in the lower crust.