Gravity anomaly due to active faults and crustal rheology in the northeastern Japan arc inferred by fault dislocation model

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Short-wavelength Bouguer gravity anomaly reflects crustal structures including effective elastic thickness distribution in the northeastern (NE) Japan arc [1-3]. Moreover, earthquake epicenters and active faults tend to be located in the region of the negative gravity anomaly or high gradient in the anomaly in the NE Japan arc [1-3]. Following the relationship between gravity anomaly and active fault distributions, Yamazaki and Nagahama [4] derive an equation of static gravity change by volumetric strain due to fault dislocation, and argue that active faults contribute to Bouguer gravity anomaly in the NE Japan arc. On the other hand, seismicity and active fault distribution tend to be located in the region with high gradient of thermal gradients or along the boundary between high and low seismic wave velocity [5-7]. Thermal gradient and seismic wave velocity reflect mechanical behaviors (viscosity and elasticity) and they are indices of crustal rheology. However, relationship between gravity anomaly and the influence of the inhomogeneity in crustal rheological structures including active fault distributions have been not unknown yet. In addition, although large positive gravity anomaly is expected along the Ou-backbone Range by its pop-up structure, negative or small positive gravity anomaly zone exists along the Ou-backbone Range. So, we study relationship between gravity anomaly and rheological properties in the NE Japan arc. First, we calculated gravity anomaly due to volumetric strain by fault dislocation model in a homogeneous elastic half space. In this case, considering compressive stress field that has continued since 3 Ma in the NE Japan arc, we give total fault displacements in the 3 million years to active faults. This model calculation generates negative gravity anomaly less than 15 mGal around active faults and these generally agree with some negative areas of short-wavelength Bouguer gravity anomaly (such as the Ou-backbone Range, Yamagata Basin and the Niigata Plain). Next, we compare short-wavelength Bouguer gravity anomaly with three available datasets in the NE Japan (thermal gradient, crustal strain rate and P-wave velocity) along the two transects created normal to the arc. This comparison reveals the correlation between negative peak in the gravity anomaly and the peaks of thermal gradient and contraction, and negative peak of P-wave velocity around the Ou-backbone Range. The comparisons suggest the relationship between gravity anomaly and crustal rheology, and that contraction along the Ou Backbone Range produces negative gravity anomaly. The result also explains the relationship between gravity anomaly and seismicity and active fault distributions since both of them distribute to transitional areas of crustal rheological structures. Hasegawa et al. [8] pointed out that reverse faults and large contraction along the Ou Backbone Range reflects the heterogeneity in rheological properties in the NE Japan arc. Therefore, those comparisons imply that reverse faults and anelastic contraction produce continuous negative gravity anomaly along the Ou-backbone Range. Finally, we propose that the gravity anomaly can be an index of the heterogeneity in crustal rheology.

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Keywords: gravity anomaly, crustal rheology, fault dislocation model