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Geometry of pressure source beneath Izu-Oshima inferred from vertical component of volcanic deformation

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In Izu-Oshima Volcano GPS observation of volcanic deformation has been conducted since 1990s, and it is suggested that the volcano is continuously inflated in long-term. Onizawa el al.(2012) investigated intensively on the long-term change of the deformation by the GPS displacement data, picking up observation points which had no data gap caused by replacement of the GPS antenna. Analyzing the three component displacement of the long-term change using the Mogi model with altitude correction, a pressure source was estimated located beneath the northern part of the summit caldera at depth of 6.68km. We carried out further research on the deformation and on the source.

The displacement at each station, depending on the horizontal distance from the source, has following features: for horizontal component, the displacements by the observation and by the calculation using the Mogi model are similar to each other; for vertical component, the observed and calculated values are rather different, that is, the vertical displacement (uplift) is largest at 0km distance by the calculation, though the observed uplift has no clear dependence on the distance from 0km to 5km, exactly speaking, the uplift at 0km distance is a little smaller than at 2 or 3km. The observed long-term displacement in Izu-Oshima cannot be fully explained by the Mogi model especially for the vertical component in the summit area, namely the observed uplift is smaller than expected.

The difference can be caused by some factors such as topography of volcano, underground structure and a pressure source of not simple shape, all those are not accounted in Mogi model. In order to understand the long-term deformation in Izu-Oshima precisely, it is necessary to consider these factors to analyze the displacement. In our investigation finite element models with various shapes of the deformation source were utilized, assuming axisymmetric structure and topography. The source has a prolate spheroidal shape elongated vertically with aspect ratio from 1.0 to 4.0 as a parameter. The source depth, the other parameter, was in a range from 3.0km to 8.0km. The finite element analysis was carried out with all combinations of parameters to solve the horizontal and vertical displacements on the surface.

Searching in the parameter space, we found that calculated value was most similar to the observation when the source depth was about 4km and the aspect ratio was larger than 3. The uplift around the summit, that was a little less than in the surrounding area, was realized by the model. Compared with the case of the Mogi model, the source depth was quite shallow and the change of source volume was about a half. A calculation on a finite element model with the uniform structure implied that the shape of the source had larger contribution to the feature of deformation than the underground structure.

Keywords: volcano, Izu-Oshima, crustal deformation, finite element analysis