Depth and radius of a magma chamber that formed the Shishimuta caldera, central Kyushu, Japan

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Based on the elastic-plastic theory, we have attempted to formularize the relationships between the depth of the magma chamber and the radius of the caldera and between the necessary volume change of the magma chamber for caldera formation and its depth, and have succeeded in finding the solutions in both a point source model and a finite spherical model. In this study, we applied the solutions to estimations of a magma chamber that formed the Shishimuta caldera, and we discussed usefulness of the solutions and validities of the model.

The Shishimuta caldera is a buried caldera estimated by detailed geological and geophysical surveys and has diameter of about 8 km, and caldera wall having dip angle of about 60 degree (Kamata, 1989). From these information, we attempted to estimate the depth and radius of a magma chamber that formed the Shishimuta caldera.

Because the Shishimuta caldera has been formed in the shallow andesitic crust, Poisson's ratio and an angle of internal friction were assumed to be 0.20 and 30 degree, respectively. If the dip angle of the caldera wall is 60 degree, the ratio (a/d) of the depth (d) and radius (a) of the magma chamber is given as 0.55 by Kusumoto (2007). In this case, the relationship between the depth of the chamber and radius (r) of the caldera, d = 0.89 r, is given. Substituting the radius of the Shishimuta caldera (r = 4 km) into this equation, we obtained d = 3.6 km and a = 2 km from a/d = 0.55.

Although the depth of the chamber given in this study is about 5 km shallower than the depth given by geological viewpoints, this geological depth of the chamber was estimated by analogy of relationship (Aramaki, 1971) between the radius of the caldera (Aira caldera) caused by activity of other islands arc volcano and the depth of magma chamber (7-10 km). Thus, in order to clarify the certainty in applications, we applied our solution to the estimation of the depth of the magma chamber that formed the Aira caldera. As a result, the depth of 8.5 km was given, and it was shown that our solution does not give incorrect answer.