Volume change of the magma chamber for the caldera formation - comparison between the finite sphere and point source models -

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We show the analytical solution on the volume change of the magma chamber for the caldera formation by finite sphere model.

Numerous field studies, laboratory experiments and numerical simulations have been attempted to explain the mechanism of caldera formation. Recent laboratory experiments and field researches have shown that the size and depth of magma chamber are important factors governing the type of caldera eventually formed. However, the quantitative relationships and expressions between caldera geometry and depth of the magma chamber have not been given yet, and the physical meanings of the coefficients of the equations given by numerical simulations have been unknown (e.g., Kusumoto and Takemura, 2005a: EPS).

Therefore, Kusumoto and Takemura (2005b) tried to get the analytical solution on the volume change of the magma chamber for the caldera formation by the point source model. As a result, it was found that the necessary volume change of the magma chamber for caldera formation is proportional to the three-power of the depth of the magma chamber. In addition, the proportionality coefficient is dimensionless and includes the compressive strength, Lame's constants, angle of internal friction and the constant which depend on the elastic constants of the medium.

The limitations of the point source model are well known. Thus, we employed the finite sphere model given by McTigue (1989). The collapse of the magma chamber was approximated by the contraction of a sphere in an elastic medium, and the stress field on the surface was evaluated using the Coulomb failure criterion under the assumption of an elastic-perfectly plastic material.

As a result, it was found that the analytical solution on the volume change of the magma chamber for the caldera formation by the finite sphere model consists of two terms. The first term is the same form as the analytical solution given by the point source model and the necessary volume change of the magma chamber for caldera formation is proportional to the three-power of the depth of the magma chamber. The second term is the correction term that has the effects of the finite sphere. In addition, the depth of the magma chamber is included in this term. Therefore, it was indicated that the depth of the magma chamber is one of the important factors for caldera formation.