Relationship between the volume change and depth of the magma chamber for the caldera formation

Shigekazu Kusumoto[1]; Keiji Takemura[2]

[1] School of Marine Sci. & Tech., Tokai Univ.; [2] Beppu Geo. Res. Labo., Grad. Sci., Kyoto Univ.

We show here the analytical solution between the volume change and depth of the magma chamber for the caldera formation.

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. In addition, this finding is supported by the numerical simulations.

In this study, we got the analytical solution between the volume change and depth of the magma chamber for the caldera formation. A spherical model was employed here instead of the ellipsoidal model widely regarded as the common shape of a magma chamber to facilitate mathematical treatment.

The collapse of the magma chamber was approximated by the contraction of a sphere in an elastic medium, and the 2-D distribution of plastic and/or rupturing area on the surface was calculated using the Coulomb failure criterion under the assumption of an elastic–perfectly plastic material. As a result, it was found that the necessary contraction (volume change of the magma chamber) for the formation of a caldera is proportional to the third powers of the depth of the magma chamber. The proportional coefficient is mechanical constant that depends on the compressive strength, angle of internal friction and rigidity.