Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SVC46-P09 Room:Convention Hall Time:May 25 18:15-19:30

Estimating of the maximum volume of magma accumulation in the crust before a large volcanic eruption

FUJITA, Shiori[1*] ; SHIMIZU, Hiroshi[2]

[1]Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, [2]Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University

Massive volcanic eruption, which emits several hundred cubic kilometres of magma and often forms huge calderas afterwards, occurs around once in every 10000 years in Japan. Although it is necessary for a huge amount of magma to accumulate in the crust for such a big eruption, there has been little quantitative analysis to determine the critical value of mechanical magma accumulation in relation to the depth and shape of the magma chamber and magma accumulation rate.

While the long-term magma accumulation rate at the volcano was estimated to be about 0.001-0.01km^3/yr inferred from the magma volume of past eruption, Druitt et al. (2012) suggest the possibility that a massive store of about 10km^3 magma had accumulated for around just 100 years before the eruption, based on an analysis of Mg concentration in plagioclase crystals of Santorini pumices. This result indicates an extraordinarily large magma accumulation rate of 0.05-0.1km^3/yr, and recently such a huge rate has actually been observed in some volcanoes. For instance, Chang et al.(2010) obtained a magma accumulation rate of 0.06-0.07km^3/yr in 2005-2008 from GPS and InSAR survey at Yellowstone caldera. InSAR observation also indicated a magma accumulation rate of 0.03km^3/yr at Uturuncu volcano in Bolivia (Sparks et al.2008). These research results show that in some cases magma is able to move abruptly upward and accumulate for a term of at least 100 years. Because the stress relaxation time of the crust as viscoelastic body is much longer than this time scale, the response of the crust to such a speedy magma accumulation can be treated as elastic deformation.

In this study, we posit the volume of magma accumulation in the crust which is possible over a time period shorter than the stress relaxation time of the crust. We calculate crustal deformation, strain and stress based on several magma chamber's depth, shape and volume pattern, and compare these with the limit strain of the crust. We presumed the shape of the magma chamber to be a sphere, dyke, or sill with a depth of several to a dozen kilometers. We used the crustal deformation calculation model for an elastic body proposed by Okada (1992).

We assumed a spherical magma chamber 10km deep and a volume change of 10km^3 when the magma accumulation rate is huge, and therefore the crust is regarded as a perfect elastic body. In this case, the strain value exceeded the crustal limit strain of 10^{-4} within a 30 km radius. This result indicates the crust around magma chamber yields and plastic deform before 10km^3 accumulation or causes brittle fracture as to a spherical magma chamber 10km deep.

Keywords: large volcanic eruption, magma accumulation, crust, strain, stress, caldera