V033-001 Room: C310 Time: May 29 13:30-13:42

Long-distance horizontal movement of subsurface melt from the Miyake-jima volcano: a vacuum cleaner model

Shuhei Okubo[1]

[1] Earthquake Res. Inst. , Univ. Tokyo

[1]Introduction

The Miyake-jima volcano, Japan, situated on the northern tip of the Izu-Bonin arc started a peculiar and unexpected sequence of volcanic activity on June 26, 2000. On July 8, the volcanic activity entered a new phase. The old summit caldera floor suddenly collapsed to form a 5E7 m^3 crater (diameter of 500 m and depth of 200 m) within 4 minutes (Nakada 2000). The crater grew rapidly to have a diameter of 1500 meter with depth of 450 meter by early September 2000; the capacity 5E8 [m^3]. During this caldera formation phase occurred small-scale phreatic explosions several times, but without significant change of depression rate. What surprised volcanologists is that the process was not accompanied by erupting comparable volume on the ground; volume of ejected matter is estimated to be 1-2 E7 [m^3], only a few percent of the lost volume. Where did the lost matter go ? How were the earthquake swarm linked to the volcanic activity nearby ? These are primary motivations for this study.

[2] Flow network in the swarm area as revealed by the scaling law of earthquakes

More than 10 earthquakes of M=6 (mostly normal faulting) occurred during the swarm episode of 2 months. It is natural to assume growth of tensile cracks from the fault tip in the vertical direction (= maximum compression axis) (Nemat Nassel & Horii). We believe the tensile cracks are responsible for effective lateral transport of the Miyake-jima magma to the swarm area. In the following, we estimate physical properties of the area as a porous media.

Earthquake scaling law (Kanamori & Anderson) gives dislocation U=60cm for a normal fault of M6.0. It follows that open cracks should have tensile opening as large as 60 cm. On the other hand, crustal movement data suggests that total tensile opening in the swarm area is 6 m on a vertical plane (L=15km, W=10km). Hense, equivalent number of cracks across the cross section should be 6[m]/U = 10. Since a M6 earthquake has a fault dimension of 5kmx5km, open cracks should have the similar dimension. These parameters give intrinsic permeability of the swarm area as an equivalent porous medium.

[3]Volume and time constant of magma flow.

The horizontal pressure gradient can be estimated by assuming vacuum space at the open crack tips while assigning lithostatic pressure at the magma source (depth 10km). Assuming the magma viscosity Nu=5E4 [Pa sec], we may estimate flow rate over a unit area as q=3E-6 [m/s] from Darcy's law.Since the effective cross section area of the swarm zone is A=3E7 [m^2], the magma squeezed to the swarm area is Q=q A = 1E2 [m^3/sec]. The velocity of the flow is estimated as v=5E-3 [m/sec], which implies that it takes T=L/v=3E6 [sec]= 35 days for a fluid particle to travel through the swarm area. It is interesting to note that T agrees with the observed duration of the earthquake swarm activity T0=50 days. The volume transported in this period amounts to Vt= Q T0 =4.3 E8 [m^3], which excellently agrees with the lost volume on the Miyake-jima volcano.

[4]Conclusions

The seismological scaling law enables us to estimate dimensions of open cracks in the earthquake swarm zone, which in turn gives fluid dynamical parameters of the equivalent porous medium. These parameters yields both time constants of swarm activity and total volume laterally transported in the area. They are in good agreement with the observation.