Quantitative examination of the effect of magma degassing on the electrical conductivity structure of a volcano

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In general, volcanic gas released from ascending magma is supposed to discharge from summit crater and fumaroles through conduit. However, recent studies indicate a case that volcanic gas budget as diffuse emission through the soil-air interface is close to that as discharging from summit crater (Allard et al.(1991)) and a possibility that volcanic gas dissolved in discharging water in volcanic aquifers is transported advectively away from a volcanic center(Rayco et al.,2008,Hernandez et al.,2008). Therefore, it is important for the quantification of volcanic gas discharge to consider the emission not only from summit crater and fumaroles but also through the volcanic edifice.

Electrical conductivity of water is very sensitive to the amount of dissolved solution. Dissolution of volcanic gas into water in a volcanic aquifer should increase electrical conductivity of water. Water with high electrical conductivity is considered to become more resistive by diffusive dissipation of dissolved solution into aquifer during transportation. This hypothesis is supported by electromagnetic observation. Kagiyama(1998) has revealed that electrical conductivity of volcanic aquifer decreases with the distance from volcanic center by VLF-MT and ELF-MT survey at Kirishima Iwo-yama volcano(SW Japan).

In this study, the authors propose the model of diffusive dissipation of volcanic gas into a volcanic aquifer in order to examine the relation between electrical conductivity of water of aquifer and the distance from the volcanic center. To simplify, following are assumed:(a)Only volcanic center discharges dissolved solution;(b)Thickness and temperature of aquifer are uniform;(c)Steady state is assumed.

The modeling uses following parameters:

a;diffusion coefficient, C;concentration of dissolved solution, r;distance from volcanic center, p;rainfall per unit time and unit area, F;discharge of dissolved solution from volcanic center per unit time.

Model.1:1-D dissipation model

(1-a)no rainfall, no water discharge from volcanic center

In this case, groundwater flow is not generated and dissolved solution dissipates by self-diffusion:

$C=-(F/a)r + C_0$

where C_0 is the concentration of dissolved solution at r=0.

(1-b)no rainfall, water discharge from volcanic center with the concentration C0

In this case,groundwater flow is generated by water discharge from volcanic center:

$C=C_0$ (constant)

(1-c)rainfall, no water discharge from volcanic center

In this case,groundwater flow is generated by rainfall:

$C=F/(pr)$

Model.2:2-D dissipation model

(2-a)no rainfall, no water discharge from volcanic center

In this case, essentially as well as (1-a):

$C=-(F/2*pi*a)\log r + Const.$

(2-b)no rainfall, water discharge from volcanic center with the concentration C_0

In this case, essentially as well as (1-b):

$C=C_0$ (constant)

(2-c)rainfall, no water discharge from volcanic center

In this case, essentially as well as (1-c):

$C=F/(4*pi*p)*1/r^2$

When the resistivity property of rock composing volcanic aquifer is uniform and dependence of electrical conductivity on temperature and hydrothermal alteration are not considered, spatial distribution of electrical conductivity structure corresponds to that of the concentration of dissolved solution.

In this presentation, the authors examine the quantitative relation between degassing rate from magma and spatial distribution of electrical conductivity structure of a volcano.