Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SVC047-P06 Room:Convention Hall Time:May 24 14:00-16:30

Monotonic infrasound at Volcan Villarrica, Chile

Akio Goto[1*], Jeffrey Johnson[2]

[1]CNEAS, Tohoku University, [2]EES, New Mexico Tech

Volcan Villarrica in the southern Andes, Chile, is an active stratovolcano that hosts a convecting lava lake in the summit crater. The Villarrica lava lake is typically overhung by spatter roof that is broken by a central skylight through which the lava lake can be glimpsed. In January 2010 we pointed a video camera at the open vent and coincidentally recorded infrasound to better understand sound generation. We observed monotonic infrasound with stable peaked frequency of 0.77 Hz although there was a lack of visual correlation between discrete explosions and infrasound production. We demonstrate that the likely source of infrasound is Helmholtz resonance produced from a cavity that separates the active convecting lava lake from an overhanging spatter roof.

When pressure perturbation is applied to an air plug in a constriction (e.g., neck of a bottle or vent skylight) that is connected to a cavity, the plug will oscillate (Helmholtz resonance). The idealized Helmholtz frequency is given by:

$f=(c/2*3.14)*(S/VL)^{1/2}$ (1)

where c is sound velocity in the cavity, S is neck cross sectional area, L is neck length and V is cavity volume. In practice, an extra air volume proportional to the neck radius moves together with the air above and below the neck. This end effect may be added to the geometrical length of the neck and is calculated as 0.85 times the radius for a flanged end and 0.61 times radius at non-flanged (pipe) end (e.g., Fletcher and Rossing [1998]). By considering the skylight as a circular flanged hole with radius r, and when skylight length is negligibly short, Helmholtz resonance frequency is given by:

$f=(c/2*3.14)*(3.14*r/1.7V)^{1/2}$ (2)

Assuming Villarrica volcanic gas concentrations is 95 mol% H_2O, 2.0 mol% CO_2, 2.1 mol% SO_2, and less than 1 mol% of other species [Shinohara and Witter, 2005] and using mixing theory for each gas species [Morrissey and Chouet, 2001], c=514 m/s assuming cavity temperature is 200 ^oC. Using this value with f = 0.77 Hz and r = 5 m (skylight radius determined from video imagery) we obtain a cavity volume of $1.04*10^5$ m^3 from eq. (2), and the cavity height is 31 m if we adopt cylindrical shape with the same diameter as that of spatter roof (65 m).Cavity gas might also mix with ambient atmosphere whose velocity is 0.85 times lower than that of Villarrica volcanic gas for the same temperatures. Although the atmosphere-volcanic gas mixing ratio in cavity is unknown, eq. (2) would predict a volume and height estimations as low as $7.51*10^4$ m^3 and 23 m, respectively, for a cavity filled with atmospheric air at 200 ^oC. The actual cavity height should then most probably be somewhere between 23 m and 31 m.

In the video we are able to identify occasional lava dripping from the edge of skylight and falling into the lava lake. Forty-four independent measurements of fall time range from 1.3 to 2.2 sec with a 1.76 s average, corresponding to free fall distances between 8 and 24 m with an average of 15.5 m if we ignore drag force of the atmosphere. The wide range in estimates could be by dynamic levels of the lava surface due to bubble slug arrival and surface disruption and poor visibility due to volcanic fume that serves to decrease the estimated fall times. For these reasons we propose that the actual cavity depth could correspond to a fall of at least 2.2 s (or 24 m). The 24 m dimension is similar to the 23-31 m estimate determined from the Helmholtz resonance model, showing the plausibility of Helmholtz resonance for observed monotonic infrasound at Villarrica.

Keywords: Infrasound, lava lake, Helmholtz resonance