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Estimation of surface tension of lava from lava stalactite and lava stalagmite appeared in lava tube cave and tree mold

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[Introduction] Inside the lava cave and lava tree mold void formed by the basalt lava flow, lava stalactite and lava stalagmite are often observed. It is a phenomenon which the droplet of lava falls from a ceiling and deposits on the floor. The estimation of surface tension of lava from the pitch of lava stalactite and size of lava stalagmite appeared in lava tube cave and tree mold void are performed and compared with various lavas.

[Estimate of surface tension from lava stalactite] Lava stalactites are positioned periodically on the surface of the ceiling wall or side wall. From the periodical pitch of the stalactites, we can obtain the surface tension of the lava. The pitch will be critical wave length of the occurrence of instability of thin liquid film attached on the surface of the ceiling of the lava tube cave or lava tree mold void. The pitch P is shown as P=$2\pi(\gamma/g\rho_L)^{1/2}$, where$\gamma$is surface tension of liquid ρ_L is density of liquid, g is gravity acceleration. From the pitch of lava stalactites on the roof surface (P=3 to 4cm), the surface tension of lava γ=$P^2 g\rho_L/4\pi^2$ was determined as 560~990 dyne/cm.

[Estimate of surface tension from lava stalagmite] After the droplet's falling either from the liquid layer of a ceiling or from a straw formed from a ceiling, the droplets of lava may be acumulated one after another on the floor. The cylindrical configuration of the lava droplet has a certain radius and length in such a way that the configuration of the droplets has almost the same size. It is thought that the surface tension of the droplet is playing an important role in this phenomenon. When it becomes impossible for surface tension to bear the weight of the droplet, the droplet will fall down. After that, again the liquid lava will be supplied, then, the droplet will repeat to fall down. Consequently many lava droplets will be deposited on a floor area. This phenomenon is very similar to the "weight of falling drops technique" which is the general method of measuring the surface tension of a liquid. Based on this idea, the study model for determining the surface tension $\gamma$of lava is made. When mass of the droplet is set to m, the force which pulls the droplet downward is f_1=mg (g is acceleration due to gravity), and the force of pulling up this upwards is $f_2=2\pi r\gamma$, where r is the radius of the lava droplet. The surface tension $\gamma$is calculable for $f_1=f_2$if the weight of the lava droplet is known. As $f_1=mg=\pi r^2 l\rho_L g$, where l is length of the lava droplet, ρ_L is the density of the lava, the surface tension $\gamma=rl\rho_L g/2$ can be obtained from r and l of the lava droplets accumulated on the floor. If we introduce ρ_L=2.5g/cm^3 and g= 980 cm/s^2, and by the fields observation of r and l, for example, the surface tension γ=490 dyne/cm can be obtained for r=0.2 cm, and l=2cm, and γ=980 dyne/cm can be obtained for r=0.25 cm, and l=4cm.

[Conclusions] The value of such surface tension obtained from the lava stalagmite is in good agreement with the surface tension acquired from the pitch of the waving of the liquid layer by the simple hydrodynamic instability model of gravity/surface tension acting on the melting liquid layer attached on the inner surface of the lava cave. This value also agrees well with the extrapolated value obtained by I. Yokoyama and S.Iizuka[1)] in the melting lava surface tension measurement experiments in Laboratory. As a conclusion, we could say that the surface tension plays a preponderant role for the lava stalactite and stalagmite formation in the lava cave and lava tree void. It seems that there is no significant difference between surface tensions of different basaltic lavas though further study for various lavas will be continued .

[References]

1) I.Yokoyama,S.Iizuka(1970):Technical Report,Hokkaido Univ. p57

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Name of Volcano, Area	SiO_2 weight%(Reference), Eruption year	Cave or T-Mold	Measured P , r and ℓ	Estimated surface tension
Mt Fuji,Inusuzumi-yama, Mitsuike-ana	49.09%(H.Tsuya) , before 7000	Cave	P=3～4cm r=0.2~0.25cm,ℓ=2~4cm	560～990dyne/cm 490～980 dyne/cm
Izu-Osima, Mihara-yama	52~53%(T.Minakami), 1951	Cave	P= ～3cm	～560 dyne/cm
Shimane,Daikon-zima	47%(I.Sawa), before 190000	Cave	P= ～3cm	～560 dyne/cm
France, Reunion, Le Piton de la Fournaise	48.8~49.8% (N.Villeneuve),1998 48~50% (A.Peltier),2004	Cave	P=3～4cm r=0.2~0.25cm,ℓ=2~4cm	560～990 dyne/cm 490～980 dyne/cm
Vietnam, Central Plateau, Chupluk Volcano	48~52% (N.Hoang)	Cave	P=3～4cm	560～990 dyne/cm
Mt Fuji,Ken-marubi, Funatsu-tainai	50.88%(H.Tsuya), 937	T-Mold	P=3～4cm	560～990 dyne/cm
Mt Fuji,Ken-marubi, Yoshida-tainai	50.88%(H.Tsuya), 937	T-Mold	P=3～4cm	560～990 dyne/cm
Izu-Osima, Mihara-yama	52%(S.Nakano, T.Yamamoto), 1986	T-Mold	P=～4cm	～990 dyne/cm
Miyake-zima, O-yama	53~54%(T.Fujii et al),1983	T-Mold	r=0.1~0.25cm, ℓ=5cm	610～1530 dyne/cm
Hachijo-zima,Nishi-yama,	50.4~50.5%(M.Tsukui), Before 1100	T-Mold	P=3～4cm, r=0.2~0.25cm,ℓ=2~4cm	560～990 dyne/cm 490～980 dyne/cm
US,Oregon,Newberry Volcano, Lava cast forest	49～50%(J.Donnelly), Before 7000	T-Mold	P=3～5cm	560～1740 dyne/cm