Experimental investigations on rheology and microstructure of the 1946 andesitic lava from Sakurajima volcano, Japan

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In this study, high-temperature viscosity measurements and microstructural analyses were done for the andesitic lava effused at 1946 from Sakurajima volcano, the Showa lava, to examine the effects of suspended crystals on rheology of highly crystalline magma. In historic times, lava flows effused at least five times in Sakurajime volcano, and the Showa lava is the latest one. Whole rock composition of the lava is representative of lavas from the volcano. The lava contains ca. 30 vol. % of phenocrysts of plagioclase and pyroxenes and its groundmass is composed of microlites and silicate glass; total crystallinity of the lava is ca. 60 vol. %. Uniaxial compression experiments were done for the lava to determine apparent viscosity using the uniaxial deformation apparatus at Earthquake Research Institute, the University of Tokyo, under conditions of temperature from 1297 to 886 K, strain rate from $10^{-2.4}$ to $10^{-5.5}$ s^{-1}, and atmospheric pressure. The run samples were processed to polished thin sections and their microstructures were analyzed using EPMA and FESEM.

Under the experimental conditions, apparent viscosity of the lava varies from ca. $10^{7.3}$ to $10^{11.3}$ Pa s^{-1}. The lava behaves as shear thinning fluid at each temperature; log apparent viscosity linearly correlates with log strain rate with the slope of -0.434 (1sigma = 0.05). In addition, apparent viscosity systematically increases as temperature decreases. At constant strain rate, log apparent viscosity shows almost linear relation with reciprocal temperature; apparent activation energy is estimated to be ca. 206 kJ, which is similar to that of silicate melt in groundmass of the lava. This suggests that the observed temperature-dependence of apparent viscosity is chiefly attributed to that of silicate melt in groundmass. At strain rate of 10^{-4} s^{-1}, relative viscosity, the ratio of apparent viscosity to melt viscosity, increases from ca. 2 to 10 as temperature decreases from 1297 to 1275 K although it is almost constant at ca. 10 below 1273 K if silicate melts in run samples were assumed to be dry.

Total crystallinities of run samples vary from ca. 0.49 at 1297 K to 0.7 at 1183 K. Relative viscosity was almost constant when crystallinity is above ca. 0.54. In contrast, it increased with crystallinity when crystallinity is below 0.54. This indicates that threshold value of crystallinity for rheological transition is around 0.52, which is lower than that for spherical particle-bearing suspensions. In addition, the plateau value of relative viscosity at crystallinity above 0.54 was several orders of magnitude lower than those of previous studies whereas apparent viscosity values seems to be reasonable compared to those of andesitic lavas measured in previous studies. We will discuss about the cause of low relative viscosity of the lava based on the results of microstructural analyses.