

## Viscosity measurements of subliquidus magmas: A Kilauan tholeiite

# Masataka Saito[1]; Hiroaki Sato[2]; Hidemi Ishibashi[3]; Hideaki Nakamura[4]

[1] Earthscience, Kobe Univ; [2] Earth and Planetary Sci, Kobe Univ; [3] BGRL; [4] Earth and Planetary Sci, Kobe Univ.

<http://www.edu.kobe-u.ac.jp/fsci-volcano/>

The viscosity measurement and sampling were performed at temperatures from 1220 C to 1165 C under 1 atm QFM buffered conditions on the Kilawean tholeiite issued from Puu Oo vent, Hawaii in June 2007. Each phase in the run product was analyzed for crystal size distribution (CSD), axial ratio, and chemical compositions to investigate the relationship between relative viscosity and textural features (crystal shape and crystal size distribution). The composition of the starting material is SiO<sub>2</sub>=50.84wt.%, TiO<sub>2</sub>=2.58wt.%, Al<sub>2</sub>O<sub>3</sub>=13.14wt.%, FeO\*=10.67wt.%, MgO=7.23wt%, CaO=10.92wt%, Na<sub>2</sub>O=2.24wt.%, K<sub>2</sub>O=0.48wt.%. On cooling, tabular plagioclase and equant or prismatic clinopyroxene increase linearly since they first appeared at 1190 C, followed by equant olivine at 1180 C.

The plagioclase contents are trace at 1190 C, 8.1vol.% at 1180 C, 11.7vol.% at 1175 C, 14.6vol.% at 1170 C, 15.0 at 1165 C. The clinopyroxene contents are trace at 1190 C, 5.6vol.% at 1180 C, 9.2vol.% at 1175 C, 12.1vol.% at 1170 C, 14.9vol.% at 1165 C. Plagioclase was slightly more abundant than clinopyroxene between 1180 C and 1170 C, and finally they attained nearly the same abundance. The olivine contents are 1.0vol.% at 1180 C, 2.5vol.% at 1175 C, 2.9vol.% at 1170 C, 2.5vol.% at 1165 C. The total crystal volume in each sample is trace at 1190 C, 14.7vol.% at 1180 C, 23.4vol.% at 1175 C, 29.6vol.% at 1170 C, 32.4vol.% at 1165 C. Each sample includes tabular plagioclase of the axial ratio of 2-8, and equant or prismatic clinopyroxene with axial ratio of 1-3. The population density of each crystal phase decreases exponentially with the size. The mean crystal size of plagioclase and clinopyroxenes+olivine are 0.028mm and 0.033mm at 1180 C, 0.027mm and 0.046mm at 1175 C, 0.034mm and 0.040mm at 1170 C, 0.038mm and 0.052mm at 1165 C, respectively. It is indicated that the axial ratio decreased and mean size of crystals increased as the temperature decreased.

During crystallization in the present experiment, the MgO content of the melt decreases from 7.23 to 5.39wt.%. The SiO<sub>2</sub> contents were almost constant, i.e.,  $\pm 0.5$ wt.% of the composition of starting material. The viscosity of melt calculated by the method of Shaw(1972) increases monotonously with the decrease of temperature; i.e., 28Pas at 1220 C, 30Pas at 1210 C, 31Pas at 1200 C, 38Pas at 1190 C, 47 Pas at 1180 C, 53Pas at 1175 C, 60Pas at 1170 C, 60Pas at 1165 C. The bulk viscosity increases from 28 to 500 Pas with temperature decrease from 1220 C to 1165 C. In particular, the viscosity increased markedly during the crystallization from 85Pas at 1180 C, 229 Pas at 1175C, 302 Pas at 1170 C, 500 Pas at 1165 C. In contrast, the viscosity varies moderately in crystal-free temperature range from 28 Pas at 1220 C, 31 Pas at 1210 C, 37 Pas at 1200 C, to 45 Pas at 1190 C. The result in this study fits with those of Shaw(1969) who also used the Hawaiian tholeiite with similar phase assemblage.

The Relative viscosity  $\eta_r$  which is the ratio of viscosity of suspension  $\eta$  over viscosity of melt  $\eta_m$ , fit those of Einstein-Roscoe-Relationship ( $\eta_r = (1-f/0.6)^{-2.5}$ ) (Marsh, 1981) where  $f$  is crystal fraction, up to  $f=29.4$ vol.%. Although relative viscosity  $\eta_r$  of suspension including thin tabular crystals was significantly higher than Einstein-Roscoe-Marsh equation (Sato 2005), the consistency can be explain by the fact that the effect of the large crystal axial ratio(2-8) was counterbalanced by the effect of the dispersion of crystal size (Ishibashi and Sato, 2006), and the presence of abundant short prismatic clinopyroxene. Present experimental result suggests that effect of crystals on the bulk viscosity is well explained by the Einstein-Roscoe equation for the Kialuean tholeiite.