Viscosity measurements of hydrous silicate melts using fiber elongation method

Akio Goto[1], Hiromitsu Taniguchi[2], Arashi Kitakaze[3]

[1] CNEAS, [2] CNEAS, Tohoku Univ, [3] Center for Northeast Asian Studies, Tohoku University

http://www.cneas.tohoku.ac.jp

Viscosity of magma depends strongly on water content. To determine the water effect on viscosity, previous works used complicated experimental procedures as follows; place glass cylinders (drilled by diamond coring tool) together with known amount of water in platinum capsules, load the capsules in high temperature and pressure vessel up to several hundreds hours for glass hydration, measure the viscosity by micropenetration method (Dingwell et al., 1996) or uniaxial compression method (Richet et al., 1996). To measure the hydrous glass viscosity easier we tried new method; combination of hydration experiments using autoclave and viscosity measurement by fiber elongation method.

We selected three samples; Tokachi-dake 1988-89 eruption essential rock, Unzen No. 4 lobe lava, and synthetic rhyolitic obsidian. Natural rock samples were ground to powder in Fe mortar to make them uniform. The rock powder was melted in Pt crucible at 1600C in furnace, held for few hours to days to make them bubble free. The synthetic samples followed the same procedure, except that they were made from the mixture of reagent grade chemicals. They were manufactured into fiber-shape, 0.4~0.8mm diameter, by dipping silica glass rod into molten sample and pulling it up. Then the glass fibers were cut to several tens of mm, and the both ends were burned to produce beads. The final length of the fibers was 15~30mm. They were hung in an autoclave, heated with water up to 500C. Preliminary study by Goto (2001) revealed that higher pressure accelerates dissolution and alteration on the sample surface. To minimize them the pressure was held up to 1.2 MPa, although alteration was almost inevitable. Before viscosity measurements we dipped the hydrated samples into hydrofluoric acid for five minutes to remove the altered layer.

FT-IR analysis confirmed that autoclave is efficient to produce water saturated samples if run time is enough. For example, the synthetic obsidian sample kept in the autoclave in 500C and 1.2MPa for 44 hours had flat water content profile perpendicular to long axis. On the other hand water content in the sample held for 20 hours at the same P-T condition decreased gradually against the distance form surface. If we adopt molar absorption coefficient 67(l/mol cm) by Stolper (1982) and density 2.3g/cm3, water content of this sample was 0.42 wt% near surface, which was the same value as the 44 hours sample, and 0.2 wt% at the center.

The prepared hydrated samples had much lower viscosity than dry melts. For example, the logarithmic viscosity (Pa s) of synthetic obsidian with 0 and 0.42 wt% water at 800C, 825C and 850C was as follows:

11.48, 9.34 (800C)
10.86, 9.00 (825C)
10.40, 8.77 (850C)

Viscosity model by Shaw (1972) expects viscosity decrease 0.64 at 800C and 0.60 at 850C on logarithmic scale for this sample. On the other hand Dingwell et al. (1996) reported viscosity decrease by 0.42 wt% water about three orders of magnitude at 800C for haplogranitic melts. In our experiments viscosity decrease was over two orders of magnitude at 800C, which is much larger than that from Shaw's model. The discrepancies between the data by Dingwell et al. and by us may be due to the difference of chemical compositions for used samples.

We confirmed that our experimental system enables us to measure the viscosity of hydrous silicate melts easier than previous systems.