

Rheological properties of Izu Oshima lava

*Akio Goto¹

1. Center for Northeast Asian Studies, Tohoku University

Apparent viscosities were estimated for 1950-1951 and 1986 lava flows effused from summit crater, based on the observed lava flow thickness, lava surface velocity and slope angle (Murauchi, 1950; Minakami, 1951; Shirao, 1986). They ranged 1.7×10^4 Pa s (1063 °C) - 3.3×10^6 Pa s (1048 °C) in 1950, 5.6×10^2 Pa s (1125 °C) - 2.3×10^4 Pa s (1038 °C) in 1951 and 1.7×10^4 Pa s - 1.2×10^7 Pa s for LA lava in 1986 (no temperature data). These values are curious in that the viscosity of 1950 lava changed over two orders within 15 °C, and 1950 lava at 1048 °C had over two orders higher viscosity than 1951 lava at 1038 °C. Minakami (1951) also pointed out that the apparent viscosities from observation were several tens times higher than the measured viscosity in laboratory. Systematic study has not been done for Izu Oshima lava rheology thus far. In the present study the viscosity of natural rock samples from Izu Oshima lava, mainly 1986 LC lava, was measured by uniaxial compression viscometry with temperature and stress range between 1000 °C and 1100 °C and 0.057 MPa and 10 MPa, respectively, at Earthquake Research Institute, University of Tokyo. Cylindrical cores with 15 mm diameter and 30 mm high were used for viscosity measurements. Viscosity was derived from deformation rate and sample dimension using Gent's equation (Gent, 1960).

Contrary to the expectation before the experiment that the viscosity decreases continuously with increasing temperature, Izu Oshima lava becomes deformable drastically at around 1100 °C. Below this temperature viscosity changes continuously with temperature, although there are over one order scatters among used cores at the same temperature. Their minimum values are 2.1×10^{12} Pa s at 1059 °C and 1.7×10^{11} Pa s at 1082 °C. These values are almost at solid state and much higher than the observed viscosity. At the temperature that the sample becomes deformable, the main factor of the deformation was not viscous flow but brittle failure. Once the sample started to deform under constant stress, deformation rate increased with time. Or when the constant compression rate was applied, stress decreased drastically with time, which is in contrast with viscous flow that stress goes constant by balancing with applied strain rate. The drastic deformation tended to occur at lower temperature when the applied stress or strain rate was high. The samples after the drastic deformation had vertical cracks on its surface, and in case the compression stroke was large (a few mm) the middle of the cylindrical core was crushed and their surface skin pushed out brittly. Bistered surface gave us doubt that the oxidized strong surface layer sustained the applied stress before the drastic deformation, but the experimental result under reductive atmospheric condition ($\text{CO}_2 + 5\% \text{H}_2$) was similar with those done under atmospheric air, indicating the influence of oxidation is minor on the rheological behavior of the used sample.

The present study indicates the Izu Oshima lava was almost at solid state below 1100 °C, and above this temperature the main factor of the deformation was not viscous flow but brittle failure. These imply the displacement of Izu Oshima lava was not by Newtonian flow, and these rheological properties may be the source of the above mentioned curious observed viscosity.

Acknowledgements

I am grateful to Prof. Hiraga and his students K. Sueyoshi and K. Yabe for their supports on viscosity measurements. This study is supported by grant in aid for cooperative work from Earthquake Research Institute, University of Tokyo.

Keywords: Izu Oshima, viscosity, rheology